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AMERICAN ENGINEER TESTS.

Locomotive Draft Appliances.

V.

Report of Meeting of Committee of Railroad Representatives.

First Installment of Report by Professor Goss, of Purdue University.

From the inception of these tests the support of the railroads has been hearty, generous and practical. Many offers of assistance have been made, and for the construction of the special apparatus a number of the large roads offered the use of shops and material. Others offered assistance in testing and the use of locomotives.

To secure the advantage of the many years of experience of railroad officers in connection with the tests, copies of Mr. Vaughan's report were sent to a number of motive power men who had expressed an interest in the undertakings. At a meeting called in Chicago May 21, 1901, by the American Engineer, the following gentlemen were present or represented:

Mr. Robert Quayle, Chicago & Northwestern; Mr. A. W. Gibbs, Pennsylvania; Mr. G. R. Henderson, Atchison, Topeka & Santa Fe; Mr. F. H. Clark, representing Mr. F. A. Delano, Chicago, Burlington & Quincy; Mr. W. H. Marshall and Mr. H. F. Ball, Lake Shore & Michigan Southern; Mr. F. M. Whyte, representing Mr. A. M. Waitt, New York Central & Hudson River; Mr. W. S. Morris, Chesapeake & Ohio; Mr. C. H. Quereau, Denver & Rio Grande; Mr. C. A. Seley, Norfolk & Western; Mr. J. E. Sague, American Locomotive Company; Mr. E. M. Herr, who was Assistant Superintendent of Motive Power of the Chicago & Northwestern when the Master Mechanics' Association tests of 1896 were made. Professor Goss, of Purdue University, and Mr. H. H. Vaughan, were also present; the American Engineer and Railroad Journal being represented by Mr. G. M. Basford.

The origin of the plan and its scope were briefly stated by Mr. Basford, also the fact that Professor Goss had made a report upon Mr. Vaughan's paper, that Purdue University had made a generous offer of the laboratory work at its actual cost and that the American Engineer would bear the expense of the tests. He expressed appreciation of the cordial reception of the plan and of the high character of the preliminary work by Mr. Vaughan and Professor Goss. By aid of these gentlemen the subject was presented in concrete form for discussion at the meeting.

It was also explained that the work would be undertaken at Purdue, under the direction of Professor Goss, and that his complete report on the tests would be published in the columns of the American Engineer and Railroad Journal.

The meeting then took up Mr. Vaughan's report, which has already been printed in full in these columns, and a number of points were brought forward and possible explanations offered. Mr. Gibbs asked for opinions as to whether the highest possible vacuum was really the most efficient, giving instances in which contraction of the nozzle with consequent increase in back pressure had led to diminished coal consumption. It was pointed out that the performance of the engine, considered as a whole, might not be at the best when running with the largest possible nozzle, since in that case the action of the draft on the fire might lead to such manipulation by the fireman that the combustion was not complete. As a lighter draft with its consequent decreased action on the fire would lead to a thin fire being caried—with excess of air admission and less efficient combustion as compared with a greater draft, fairly thick fire and economical combustion. The total result certainly depended on the fire to a far greater extent than on the efficiency of the front end; yet such facts would not affect the desirability of using the most efficient stack and nozzle, as when this was obtained the draft could always be increased by reducing the area of the nozzles.

Answering a question of Mr. Gibbs as to the vacuum in the front end being a measure of the efficiency of the stack and nozzle, it was pointed out that with the same conditions in the front end the vacuum will vary with the condition of the fire, a thicker fire causing greater resistance to the flow of air at that point, and thus leading to the vacuum being greater, while the flow of steam from the nozzle remained the same.

Explanations were made by Mr. Herr of the difficulties at first experienced by the Master Mechanics' Association Committee owing to this cause, and the impossibility of obtaining any comparative results until oil was substituted as a fuel. It was also stated that while the variations in front-end vacuum due to variations of the position of the nozzle are comparatively small, those due to the condition of the fire are extremely large, and it was unanimously decided that it would be necessary to use oil in the proposed tests.

The influence of the state of the fire led to an inquiry from Mr. Gibbs as to whether it would not be necessary to include in series No. 1 of Mr. Vaughan's report another variable in addition to those mentioned, namely, variation in grate areas, and it was decided that tests ought to be made with three areas of grate opening, one of which was to be 80.72 sq. ins., the same as used in the Hanover tests; another with 150 sq. ins., used in the tests of the Master Mechanics' Association Committee, and a third with a larger area of about 200 to 220 sq. ins. As pointed out in the report it is probable that the amount of air that is moved by the jet would greatly affect the size of the best stack—a stack that would be the best in the small grate would not be the best with a large grate, and

as this question is very important, in view of the increased size in the grate now generally used, as others are not taken into consideration, the tests would not be reliable with respect to the different sizes of grates. A large number of suggestions as to methods of measuring the amount of air handled were offered, but none were regarded as being practically superior to those formerly employed.

It was suggested by Mr. Marshall that it would be advisable to make at first a number of tests on the Purdue locomotive, or a larger one if necessary, in which the stacks and nozzles used should agree closely with those used in the Hanover tests. That if a complete series of tests with one or two series of stacks were made it might be possible to deduce from these the necessary modification that must be made to the Hanover tests to adapt them to locomotive conditions and that afterward by a few observations, checking results here and there in the Hanover tests, sufficient would be known, with the aid of those tests, for all practical purposes.

This was agreed on as the series with which the work should commence, and after further discussion it was decided that the investigation of the petticoat pipe and a final decision as to whether or not advantages were to be gained from its use should be taken up later.

It was decided that tests referring to the length of the front end and the loss in efficiency caused by the baffle plate would not lead to results of much practical advantage at present, and not of such importance as the above outlined series.

In many respects the recommendations in Mr. Vaughan's report were approved, the substitution of the series suggested by Mr. Marshall for the investigation proposed by Mr. Vaughan of the action of the jet being the most important. A great many suggestions were made and features of importance discussed, in fact, so many that it is impossible to refer to all, and the detail methods of conducting the tests were fairly well settled.

Those present resolved themselves into a committee for the presentation of the tests on the locomotive front end, to be known as the American Engineer Tests on Locomotive Draft Appliances, and at Mr. Henderson's suggestion all agreed to forward to Mr. Basford all articles, data, etc., that came under their observation in connection with this subject.

Immediately after this meeting the preparation of designs for the special apparatus began. The work now being sufficiently advanced. Professor Goss has submitted the first installment of his report, as follows:

AMERICAN ENGINEER TESTS OF LOCOMOTIVE DRAFT APPLIANCES.

TESTS OF LOCOMOTIVE STACKS.

Report by Professor W. F. M. Goss.

Engineering Laboratory, Purdue University,
Lafayette, Indiana, January 1, 1902.

The American Engineer,
Mr. G. M. Basford, Editor, New York City.

Sir: In obedience to your direction, the Engineering Laboratory of Purdue University has made certain tests of locomotive stacks, upon which I now submit the following report:

I.

Introductory Statement.

1. The Stack Problem.—A review of published accounts of previous experiments, involving draft appliances, which have been made under service conditions, indicates that but slight attention has hitherto been given the stack. This, probably, is not due to any lack of appreciation of the importance of the stack, but rather to the complicated nature of the whole problem, and doubtless also because the need of information concerning other details has been deemed more urgent. However this may be, the fact remains that but little effort is at present made to accurately proportion the dimensions of stacks for the work they are to accomplish. On the contrary, it not infrequently happens that one engine having 17-in. cylinders and another having 20-in. cylinders are fitted with stacks of the same diameter. The larger engine may develop two or three times as much power as the smaller, and its larger volumes of furnace gases and of steam must all find their way through an opening which apparently is not too large for the smaller engine. It is, in fact, the practice of some roads to make practically all stacks of the same diameter, without reference to the size of the engine upon which they are used. In such cases it is not likely that stacks are often given dimensions such as are required for highest efficiency. Moreover, conditions such as have been described do not prevail from choice, but rather because the information which will serve to guide practice along more logical lines is not available. There is urgent need for facts. So far as we can see, the stack will never be omitted from the steam locomotive, and it is but reasonable to expect that in each individual case some particular diameter, length and contour will give a more efficient result than other dimensions or contour. Upon this theory, the pres-

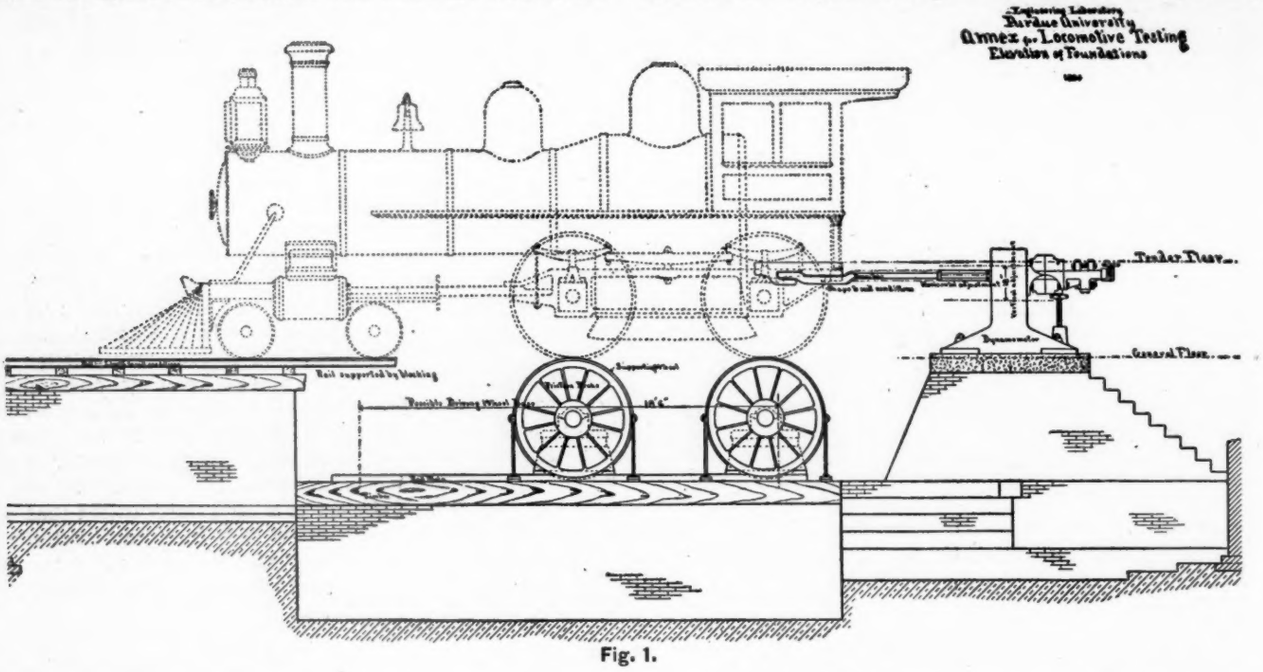


Fig. 1.

ent research has been promoted. It has been the expectation that it would serve to develop a sufficient array of facts to constitute a foundation for a theory which may hereafter guide in the logical design of such apparatus.

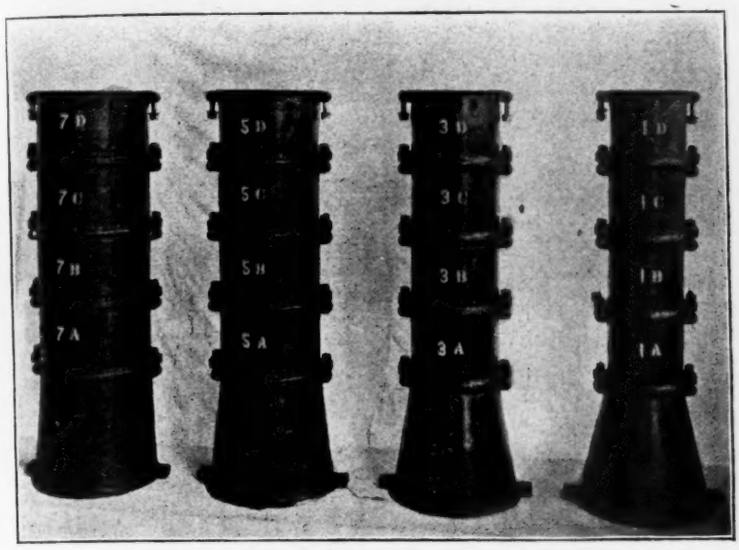


Fig. 2.

2. The Purdue Locomotive Testing Plant, in connection with which the tests were made, has been frequently described, and the principles underlying its action are now generally understood. For this reason it need not now be described in detail. It will be sufficient to say that the locomotive employed, known as Schenectady No. 2, is of the eight-wheeled type, and weighs 100,000 lbs. The least diameter of the boiler is 52 ins., and the cylinders which were in use throughout the experiments are 16 by 24 ins. The locomotive is mounted upon supporting wheels in such a way as to provide for its complete operation while occupying a fixed position in the laboratory. It is fired in the same manner as it would be upon the road, and delivers its power from the periphery of its drivers as it would do if it were passing along the track, while its fixed position at all times permits its action to be studied with the same facility as that of a stationary plant. An outline in elevation of the plant is shown by Fig. 1, but the locomotive which is shown in connection therewith is not the one upon which the experiments were made.

3. The stacks employed in the experiments, as designed by Mr. H. H. Vaughan, and as constructed under the direction of Mr. W. H. Marshall, Superintendent of Motive Power of the Lake Shore & Michigan Southern Railway, at the Elkhart shops of that road, are shown by Figs. 2 and 3. The illustrations are from photographs taken before the work began. Fig. 2 embraces four different diameters of straight stacks, and Fig. 3 four different diameters of taper stacks. Each stack is made in sections, by the successive removal of which any desired length within the limits shown may be obtained.

The nozzles used in connection with the different stacks are shown by Fig. 4. These were designed by Prof. William Forsyth and, like the stacks, were constructed under the direction of Mr. W. H. Marshall. When in use the nozzles stand upon a short exhaust pipe, designed in accord with the recommendation of the Master Mechanics' Committee. They consist of a wrought-iron body mounted on a cast-iron base and fitted at the top with a suitable tip. All have the same diameter of tip, namely, 4½ ins.

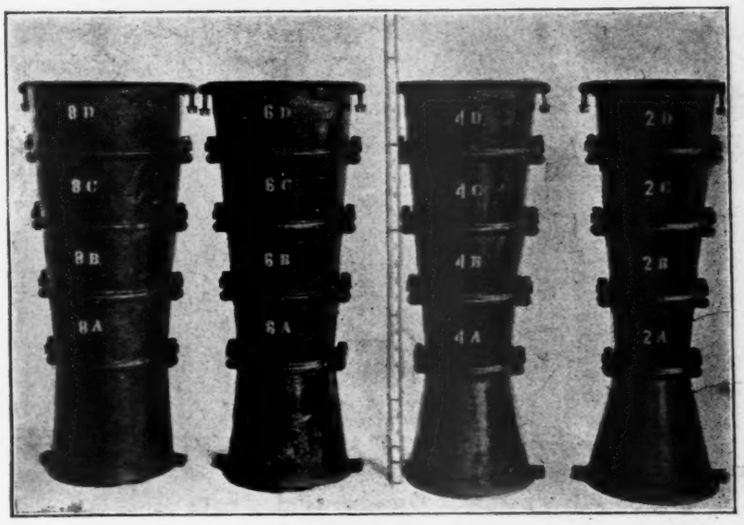


Fig. 3.

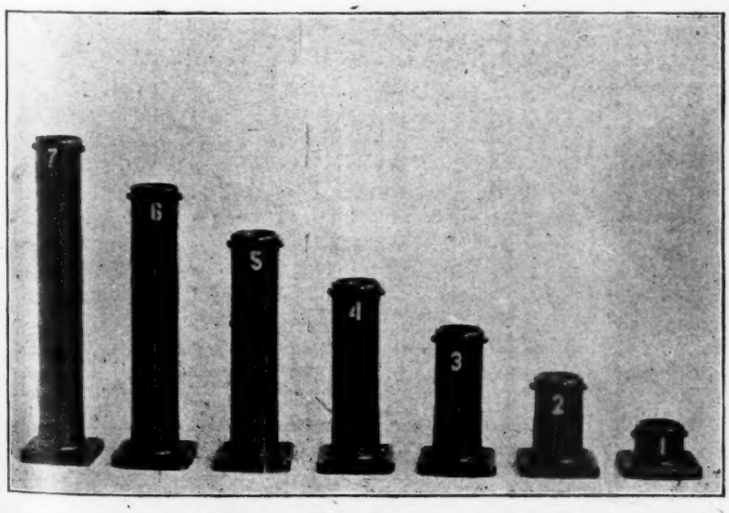


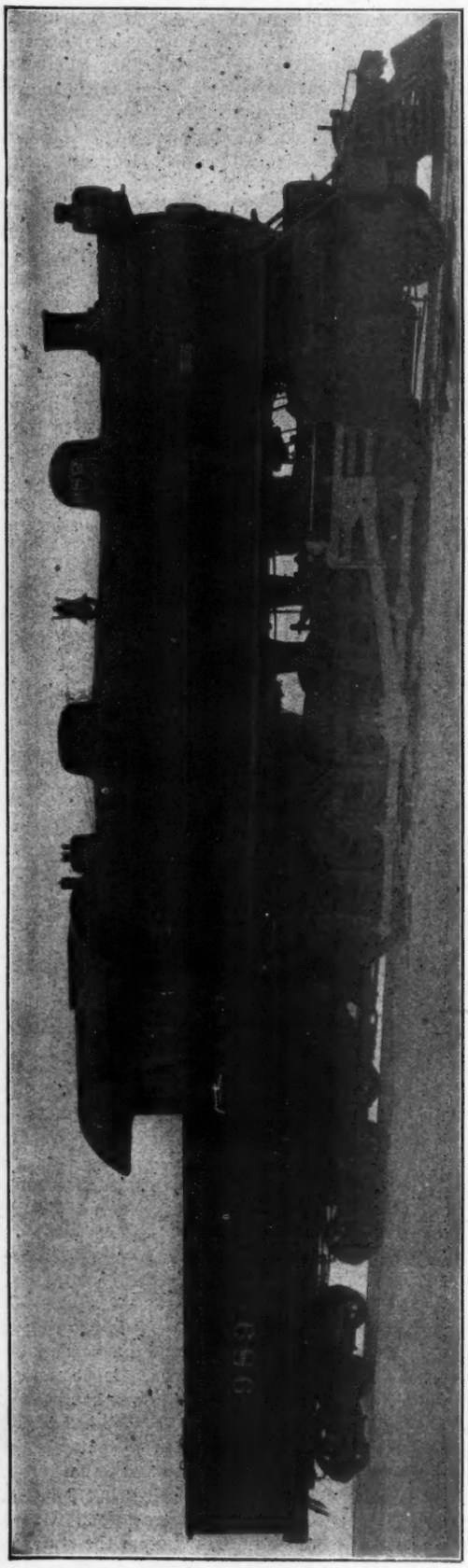
Fig. 4.

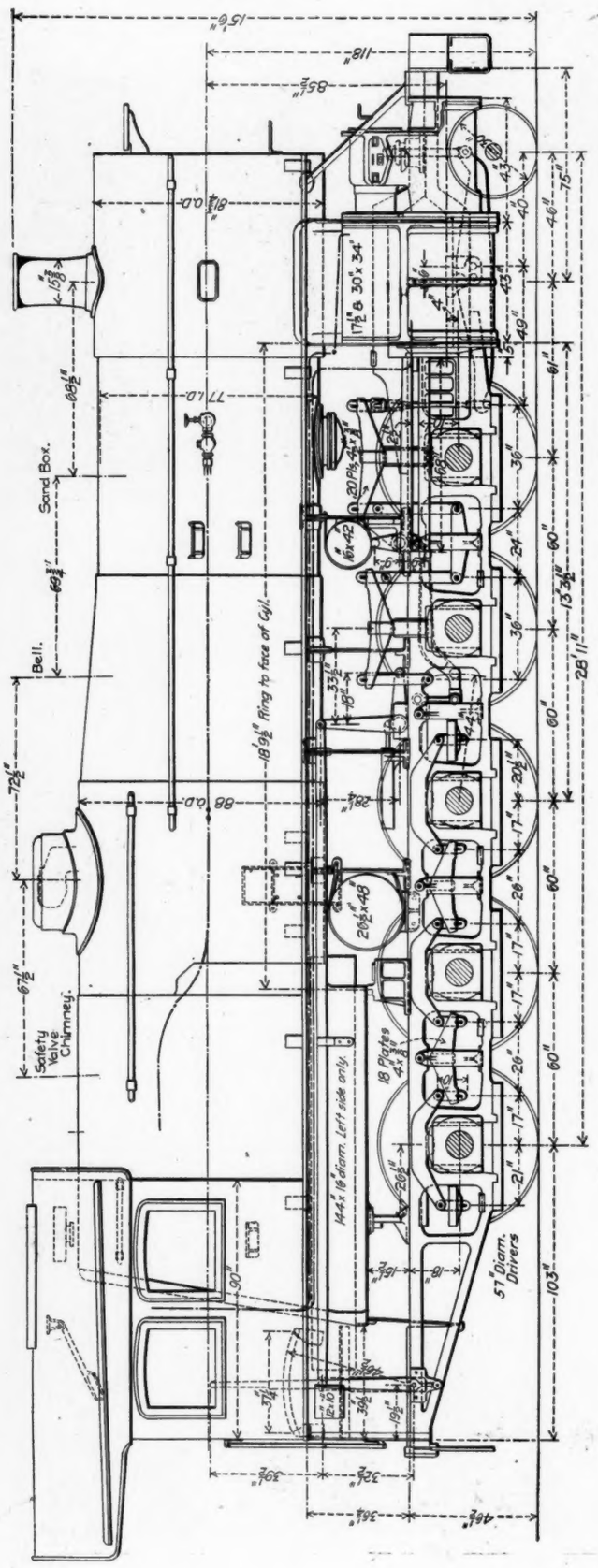
The exact dimensions of all portions of this equipment will be found of record in connection with data obtained therefrom.

(The next subject is the variables.)

(To be continued.)

A steamer using oil fuel exclusively is running in the regular service of the Shell Transport and Trading Company, of London, between Borneo and England. A series of oil supply stations has been established by this company between China and Japan and London, and these will be extended. The experience of this company shows that for oil fuel a vessel of 3,500 tons requires but 3 firemen as against from 18 to 24 for coal fuel. One man tends the fireroom in each watch, the water being regulated automatically. For oil the bunker space is about one-half that required for coal, and, furthermore, spaces not available for coal may be used for oil. In this case fuel oil seems to be perfectly successful.





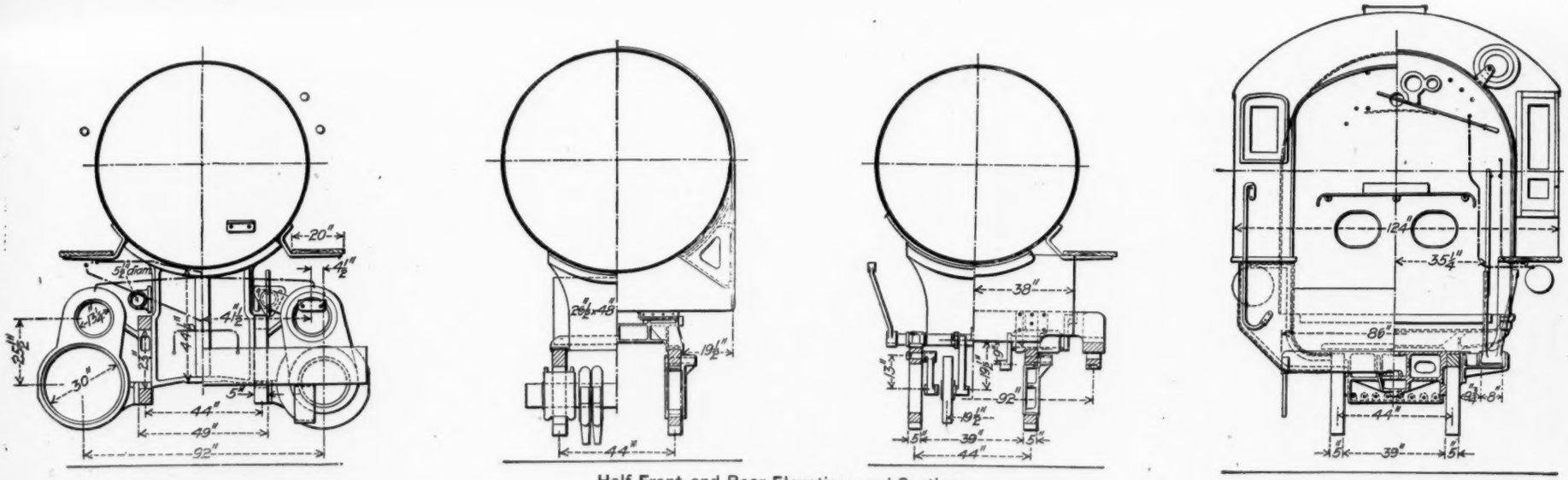
Tandem Decapod Compound Freight Locomotive—Atchison, Topeka & Santa Fe Railway.

THE HEAVIEST AND MOST POWERFUL LOCOMOTIVE EVER BUILT.

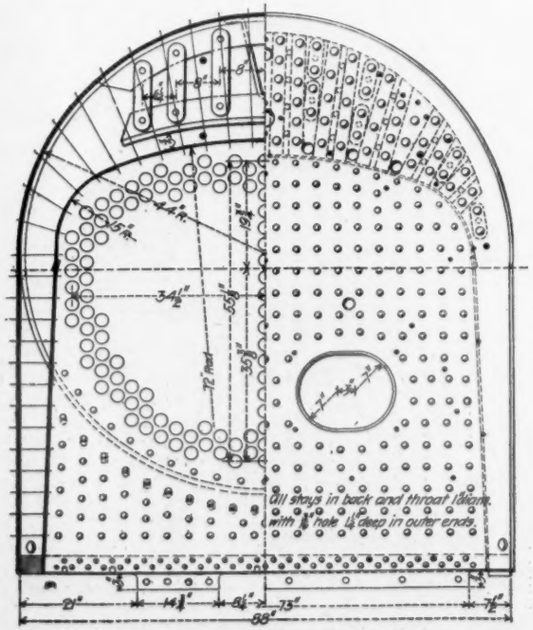
AMERICAN LOCOMOTIVE COMPANY, *Builders.*

JOHN PLAYER, *Consulting Superintendent of Motive Power.*

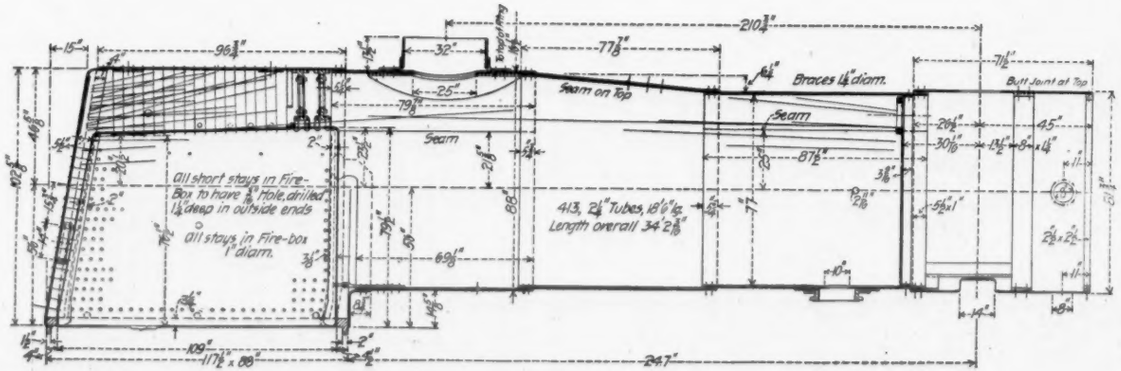
G. R. HENDERSON, *Superintendent of Motive Power.*



Half Front and Rear Elevations and Sections.



Transverse Section of Boiler.



Longitudinal Section of Boiler.

Decapod Tandem Compound Locomtive—Atchison, Topeka & Santa Fe Railway.

THE HEAVIEST AND MOST POWERFUL LOCOMOTIVE EVER BUILT.

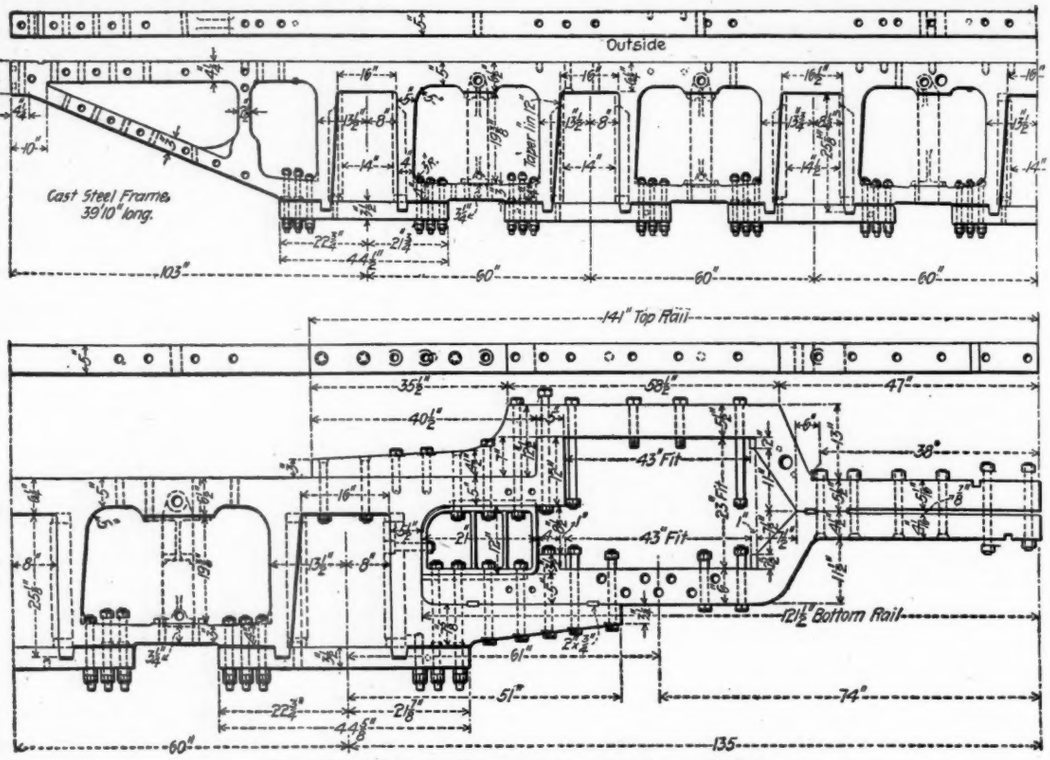
DECAPOD TANDEM COMPOUND LOCOMOTIVE.

Atchison, Topeka & Santa Fe Railway.

Heaviest Locomotive Ever Built.

Though the past four years have bought out surprising advances in the weight and power of locomotives until the limit was thought to have been reached, the Atchison, Topeka & Santa Fe has surpassed all previous efforts in a design from the Schenectady Works of the American Locomotive Company. This engine, however, is not likely to enjoy the supremacy long, according to rumors of still greater proportions which are promised for the near future. This road is leading in the matter of weight and power of locomotives, and engines in the issue referred to. The Atchison engine has a Laird crosshead.

This engine is enormous. Its total wheel base is 28 ft. 11 ins., or 11 ins. greater than any other of our record. Its driving wheel base is 20 ft., or 8 ins. greater than that of the "Soo" engine, illustrated in our volume of 1900, page 319. The total heating surface is 4,681 sq. ft., or 415 sq. ft. greater than that of the oil-burning engine for this road (page 10, January issue), which was the largest heating surface previously used. The tube heating surface is 4,476.5 sq. ft., with 413 2¼-in. tubes, 18 ft. 6 ins. long, these being the longest tubes in our record of freight engines. The tubes are spaced 13-16 ins. apart. As shown in the boiler sections, the grate is 9 ft. long by 6 ft. 7 ins. wide, and the firebox has straight sides with



Cast Steel Frames, Showing Unusually Heavy Splicing.

COMPARISON OF HEAVY FREIGHT LOCOMOTIVES.

Railroad	P. B. & L. E.	Union	Lehigh Valley	Illinois Central	Atchison	N. P.		Atchison.
Builder	Pittsburgh	Pittsburgh	Baldwin	Brooks	Baldwin	Amer. Loco. Co.		Amer. Loco. Co.
Si'ple or Comp'd.	Simple	Simple	Vauclain Comp'd.	Simple	Vauclain Comp'd.	Tandem Comp'd.		Tandem Comp'd.
Type	Consolidation	Consolidation	Consolidation	12-wheel	Consolidation	Consolidation		Decapod.
Total weight	250,300	230,000	225,082	232,200	214,600	198,000 lbs.		259,800 lbs.
Weig't on driv'rs.	225,200	208,000	202,232	193,200	191,400	175,000 lbs.		232,000 lbs.
Size of drivers	54 in.	54 in.	55 in.	57 in.	57 in.	63 in.		57 in.
Cylinders	24 x 32 in.	23 x 32 in.	18 and 30 by 30 in.	23 x 30 in.	17 and 28 x 32 in.	15 and 28 by 34 in.		17½ and 30 by 34 in.
Heating surface.	3,805 sq. ft.	3,322 sq. ft.	4,103.6 sq. ft.	3,500 sq. ft.	4,266 sq. ft.	2,997.1 sq. ft.		4,681 sq. ft.
Grate area	36.8 sq. ft.	33.5 sq. ft.	90 sq. ft.	37.5 sq. ft.	None	52.29 sq. ft.		59.47 sq. ft.
Steam pressure	220 lbs.	200 lbs.	200 lbs.	210 lbs.	210 lbs.	225 lbs.		225 lbs.
Ratio of total weight to heating surface	65.7	69.2	54.8	66.3	50.3	66.0		55.5.
American Engin'r reference	1900, page 214.	1898, page 365.	1898, page 395.	1899, page 315.	1902, page 10.	Sept., 1901, p. 271.		Feb., 1902.

its policy will be studied with deep interest. It is stated that this road will soon have 76 engines as large as this one, or larger. The heavy engine is not therefore considered experimental in this case.

The locomotive illustrated here is for road service, and is intended to replace double heading on mountain grades. Having favored the tandem compound principle for several years, this type was decided upon in this case, and the features of construction are similar to those of the Northern Pacific consolidation compounds, illustrated in our September number of last year, page 273. In fact, the design and construction are so similar to those of the Northern Pacific engines as to render it unnecessary to enter into the new design in minute detail, because of the thorough description of the Northern Pacific radial and sling stays. These engines have two firedoors. The boiler is 78¾ ins. in diameter, while that of the Pittsburg, Bessemer & Lake Erie engine (volume of 1900, page 214), is 84 ins. The center of the boiler is 118 ins. above the rail, or 1¾ in. less than the engine just referred to. In weight the Santa Fe engine surpasses all, as shown in the accompanying table, which is presented for comparison. The ratio of heating surface to grate area is 78, and the ratio of total weight to heating surface is 55.5. It is interesting to note that while this is the heaviest locomotive ever built, with reference to this ratio it stands third in the list of heavy engines which forms part of this article. A water space of 4½ ins. is provided, all around the mud ring.

The tractive power is 55,300 lbs. when operating as a com-

pound, as taken from indicator cards in actual service. In general the cylinder and valve arrangement is like that of the Northern Pacific tandems already referred to, the same arrangement of starting and by-pass valves being used. For such a large engine the frames are necessarily very heavy. They are of cast steel, 5 ins. wide, and the jaw braces are 3½ ins. deep, secured by three 1¼-in. bolts at each end. Over the driving boxes the frames are 6¼ ins. deep, and the upper frame splice extends back over the forward jaws. Naturally the driving journals are large, the main journals being 10 by 12 and the others 9 by 12 ins. The main crank pin is 7 by 8 ins., and the engine truck journals are 7 by 12 ins.

These engines are constructed for oil or coal burning, and the oil fittings will be fitted later. The tender has a straight top without a high rim. It weighs 60,000 lbs. empty, and is carried on two Player 50-ton trucks. The wheel base of the engine and tender is 62 ft. Among the special equipment is the Le Chatelier water and Westinghouse brakes, Leach sander, Monarch brake beams, three 3-in. Crosby pop valves, Boyer speed recorder, and Westinghouse friction draft gear.

For a study of this engine in comparison with other heavy ones the accompanying tables have been prepared.

Tandem Compound Decapod Locomotive, A., T. & S. F. Ry.

General Dimensions.

Gauge	4 ft. 8½ ins.
Fuel	Oil and soft coal
Weight in working order	259,800 lbs.
Weight on drivers	232,000 lbs.
Total engine and tender	394,700 lbs.
Wheel base, driving	20 ft
Wheel base, rigid	20 ft.
Wheel base, total	28 ft. 11 ins.

Cylinders.

Diameter of cylinders	17½ ins. and 30 ins.
Stroke of piston	34 ins.
Horizontal thickness of piston	5½ ins.
Diameter of piston rod	H. P. 3¼ ins., L. P. 4½ ins
Kind of piston packing	Plain rings
Kind of piston rod packing	Jerome

Valves.

Kind of slide valves	Piston type
Greatest travel of slide valves	6 ins.
Outside lap of slide valves	⅞ ins.
Inside clearance	H. P. ⅛ in., L. P. ¼ in.
Lead of valves in full gear,	Line and line F. & B., ¼ in. lead at ½ stroke cut-off

Wheels, etc.

Diameter of driving wheels outside of tire	57 ins.
Material of driving wheels, centers	Cast steel
Tire held by	Shrinkage
Driving box material	Main, cast steel; balance steeled cast iron
Diameter and length of driving journals,	Main, 10 ins. by 12 ins.; balance, 9 ins. by 12 ins.
Diameter and length of main crank pin journals,	F. & B., 5 ins. by 4¼ ins., 7 ins. by 8 ins.
Diameter and length of side rod pin journals,	Main side, 8¼ ins. by 5½ ins.; inter., 5½ ins. by 5 ins.
Engine truck, kind	2-wheel swing bolster
Engine truck journals	7 ins. by 12 ins.
Diameter of engine truck wheels	30 ins.
Kind of engine truck wheels	A., T. & F. E. pattern, 3⅜ in. tire

Boiler.

Style	Extended wagon top, with wide fire-box
Outside diameter of first ring	78¾ ins.
Working pressure	225 lbs.
Thickness of plates in barrel and outside of fire-box,	13/16, 9/16, ⅝, 1 ins.
Horizontal seams,	Butt joint sextuple riveted, with welt strip inside and outside.
Circumferential seams	Double riveted
Fire-box, length	108 1/16 ins.
Fire-box, width	79¼ ins.
Fire-box, depth	F., 79½ ins.; B., 76½ ins.
Fire-box, material	Carbon steel
Fire-box plates, thickness,	sides, ⅜ in.; back, ⅜ in.; crown, 7/16 in.; tube sheet, 9/16 in.
Fire-box, water space,	front, 4½ ins.; sides, 4 ins. to 6½ ins.; back, 4 ins. to 5½ ins.
Fire-box, crown staying	Radial, 1⅛ ins. diam.
Fire-box, stay bolts	Ulster iron, 1 in. diam.
Tubes, material	Charcoal iron No. 11
Tubes, number of	413
Tubes, diameter	2¼ ins.
Tubes, length over tube sheets	18 ft. 6 ins.
Heating surface, tubes	4476.5 sq. ft.
Heating surface, fire-box	205.41 sq. ft.
Heating surface, total	4681.91 sq. ft.
Grate surface	59.47 sq. ft.
Ash pan, style	With air openings suitable for oil burning
Exhaust pipes	Single
Exhaust nozzles	5½ ins., 5¾ ins., 6 ins. diam.
Smoke stack, inside diameter	15⅝ ins.
Smoke stack, top above rail	15 ft. 6 ins.
Boiler supplied by,	2 injectors, Nathan Simplex No. 11 R. & L., outside of cab.

Tender.

Weight, empty	58,600 lbs.
Weight, loaded	134,900 lbs.
Wheels, number of	8
Wheels, diameter	33 ins.
Journals, diameter and length	5½ ins. by 10 ins.
Wheel base	20 ft. by 4 ins.
Tender frame	A., T. & S. F. standard steel channels
Water capacity	7,000 U. S. gals.
Oil tank capacity	2,250 gals.
Total wheel base of engine and tender	62 ft.

SALARIES OF MOTIVE POWER OFFICERS.

Because it reveals so many vital questions a recent remark by a prominent railroad president seems to us one of the most important which has come to our notice in a long time. In commenting upon the operation of the very heavy locomotives of to-day it was said that there is an increasing difficulty in securing the right sort of men to whom to entrust their handling. That there is any difficulty in finding men competent to operate the largest locomotives can only be the fault of the railroads, and this is a severe indictment of railroad managements in their treatment of their motive power problems generally. While this may not be a popular subject it should not be avoided.

In the six years ending with 1899 almost merciless retrenchment and strictest economy were necessary. Trains were cut down in number, runs were increased in length, the tonnage of freight trains increased, engines became larger and more was expected of train and engine men than ever before. During this time many records for economy were earned by operating officials, and altogether, of course, a great deal was accomplished in the line of improvement. The pooling system was generally introduced and annual average mileage increased. But a railroad officer says that he does not find many satisfactory men to run the big engines. Another says that in his entire lot of engineers, and he has a large number, he does not find many worthy of promotion. There must be a reason for these things if they are really true. If the men have been treated as they ought to be, and if the attitude of their employers toward them and their work has been what it should be, the question is a fundamental one and deeper than it appears.

There seems to be comparatively little inducement for engineers to put forth their best efforts, and this should not be lost sight of by those who are seeking records. When men were assigned to engines and took personal pride in their condition and appearance more engineers were promoted to higher positions and the inducements for good men to take up this work were greater. But now the tendency is toward making them mere machines to control other machines, and to this the pooling system contributes unless special care is put into its administration. In this case the engineer is used to introduce the real subject of this discussion.

With the concentration of power in large units and a tendency toward further increase in this direction the engineer should be improving. What inducement does he find in the condition of his immediate superiors? He sees a master mechanic in charge of 1,500 men, working under a salary of $2,000 a year, and another in charge of a division of a large system, which was formerly a whole railroad by itself, who draws $1,800 a year, and a mechanical engineer who is required to be a technical school graduate, having shop experience, at $1,000 a year. Worse than these is the case of the superintendent of motive power of a road of respectable size who for years has received a salary of but $3,000. It is to the everlasting credit of these men that their devotion and care of their work have enabled them to attain the splendid results which are seen on every hand.

These things may adjust themselves in time when they are appreciated and understood and there are signs of awakening as it becomes more and more apparent that the attractions of motive power life are not what they might be. A general uplift and improvement in the positions and encouragements of this entire department is necessary. We may learn something from England with reference to the motive power officer. There

the chief locomotive officer is one of the best paid in the service, salaries being double and often more than double, those in this country and the positions are correspondingly important.

It is, furthermore, a poor reward for a faithful effort to permit a man in a subordinate position to strive for years to fit himself to succeed the head of his department only to find when the goal is reached that the salary of that position has shrunk, perhaps 25 per cent., when the opportunity came to take advantage of a new man. That this is the settled policy of one of the large roads is difficult to believe, but that this is the present practice of one of them is a fact. If a corporation actually desires to remain at a standstill as to improvements, the best way to indicate the policy is to discourage the officers and men, but of course no one intentionally establishes such a condition.

There is a well-grounded and growing belief that the commercial rating of brains of mechanical officers is too low, and that all is not done that might be done to attract to the railroad field the best mechanical skill. When a young division master mechanic can leave railroad for commercial work and step at once into a position financially equivalent to that of the general superintendent of the road he leaves, there is something wrong.

The best location of the office of the Superintendent of Motive Power, whether at the general office of the road or at the shops, is frequently a subject of discussion in visiting these offices, and it is a subject of considerable importance. A railroad officer should have his headquarters where he can best manage the affairs of his department. Some prefer to be near the principal shops, where they may easily keep in close touch with the problems continually arising in connection with repairs, and a great many are so located. There are equally strong arguments in favor of placing the general officers in intimate touch with each other, and this view appears to have the best support. In the past the importance of the functions of the head of this department in connection with repairs were relatively greater than they are now. Repairs are even more important since locomotives have become so big, but other functions have increased in importance to such an extent that this cannot now be said to constitute the chief care of the superintendent. With an efficient shop organization repair work may be even better managed if the chief is sufficiently removed to enable him to take general rather than direct supervision. The motive power superintendent to-day needs to be a business man and an engineer rather than an expert mechanic, although proficiency in mechanical work is, of course, highly desirable. He needs to be able to look above the shops to the broader principles of his work, in fact, to take a bird's-eye view of his department, and if he does this there is no danger of neglecting this branch. Furthermore, as his work affects all departments and is closely interwoven with them all he should be conveniently at hand for consultation. If he is at the shops, which are usually more or less distant from the general offices, he is not so likely to be consulted as often as he should be, with the result that often decisions in which he should have a part are made without him, and he must be heard afterward, and perhaps too late, if heard at all. This may put him in a very uncomfortable, as well as undignified position, which does not aid him in the administration of one of the most important departments of the road. It appears that those who favor placing him with or very near the other general offices have the stronger arguments. If the location of the shops interferes with this, the superintendent of motive power should be located in the general office headquarters.

Nowadays there are so many demands upon the runners of locomotives on fast trains that it is most important to provide in every possible way for the utmost economy of their attention. Schedules are growing faster and the service more severe in many ways. In inspecting a road recently equipped with an extensive application of automatic block signals, an apparent disregard of a vitally important factor was forced upon the attention, namely, that while there was no apparent desire to practice a crippling economy, comparatively few of the signals were located properly and many of them were so placed that they could be seen only when the approaching locomotive was almost upon them. This is not as it should be, and yet the serious character of the fault has probably escaped the notice of those who were responsible for the installation. On a crooked road, and this is a very crooked one, it is customary to use distant signals, working with the home signals where the latter must be located in the midst of sharp curves. This was done in this case, but as the distant signals were placed on the same masts with the home signals, they, to say the least, failed to correct the fault and remove the difficulty. The trouble is this: A signal which can be seen only from a certain point—as, for example, one located on a curve—fails in a large measure to fulfil its proper office as an aid to the engineer. If block signals must be placed on curves where they cannot be seen from a proper distance, they certainly should be provided with distant signals which are properly located. A properly located signal is one placed so that the enginemen can have as long a time as possible in which to take its indication and, in order to obtain their full value a great deal of care must be exercised in the location and sighting of signals. Those who are responsible for the discipline of the enginemen on the road in question should enter a vigorous protest against careless or hurried work in this important part of signal engineering. It would be advisable to insist upon having the locations determined by a committee upon which the locomotive department is represented. It would well repay motive power officers to thoroughly inform themselves as to the principles of signaling. They can easily acquire information sufficient to enable them to give valuable assistance in the planning of installations, and it is well worth their while to do so. The locomotive department suffers as much as, and perhaps more than, any other from an improperly located signal. A locomotive runner cannot do good work when he is obliged to spend a large part of his time watching for obscure signals, to say nothing of the danger of it.

RATE FIXING IN PIECEWORK.

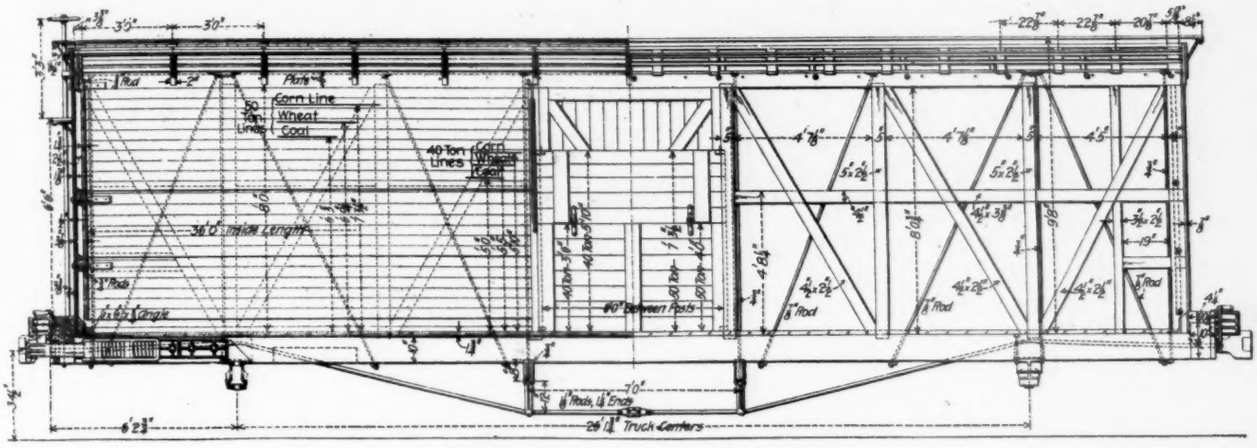
In discussing the fundamentals of a bonus plan before the American Society of Mechanical Engineers, last December, Mr. Fred W. Taylor made the following pertinent observations, which have an important bearing on the establishment of all forms of piecework. He considered the rate-fixing department quite as important as the drawing room. "Fifty years ago," he said, "few engineering establishments had a drawing room, but it is now considered to be absolutely essential to the proper conduct of a manufacturing establishment, and it is safe to say that 30 years hence a rate-fixing department will be considered fully as essential to success as a drawing room. The objection that is usually made to this department is that it is an extra expense for which there is no return. But it must be remembered that the work which it does must be done somewhere. It is usually done in the shop on the spur of the moment by the man at the lathe or the foreman, who does not give it the proper consideration as to how the work is to be done. It stands to reason, then, that a man who devotes his whole time to the subject is better fitted to carry it on than a man who has it thrust upon him and must decide off-hand as to how he will do it. When a pump is to be built the men in the shop are not told to build a pump as it may please them, but the work is first designed and drawings are furnished. The same common sense principle will apply to rate-fixing and its attendant work of specifying the method of doing this work."

BOX CAR, 80,000 POUNDS CAPACITY.

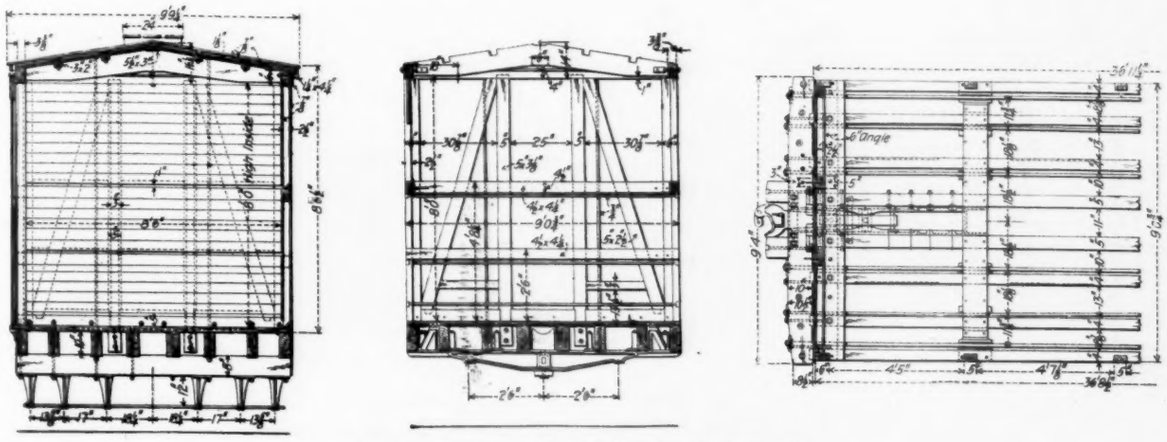
American Railway Association Standard Dimensions.

Chesapeake & Ohio Railway.

These drawings illustrate a new box car with wooden sills and metal bolsters, built for the Chesapeake & Ohio, to drawings and specifications prepared under the direction of Mr. W. S. Morris, Superintendent of Motive Power. The inside dimensions are those adopted by the American Railway Association, and the design was prepared with a view of adapting



Half Longitudinal Section and Elevation.



Sections and Partial Plan, Showing Underframing.

Box Car, 80,000 Pounds Capacity—Chesapeake & Ohio Railway.

underframes of steel, without materially disturbing the general features wherever such a substitution seems necessary. The most important dimensions are given in the following table:

General Dimensions.

Length of framing over end sills	38 ft. 7¼ ins.
Length over siding	36 ft. 10¼ ins.
Length inside	36 ft.
Length over running boards	38 ft. 2¾ ins.
Width over side sills	9 ft. ¾ in.
Width over siding	9 ft. 2½ ins.
Width inside	8 ft. 6 ins.
Width of door opening	6 ft.
Height between sill and plate	8 ft. ¾ in.
Height from floor to under side of carline	8 ft.
Height from rail to top of running board	12 ft. 11¾ ins.
Height from rail to top of brake shaft	13 ft. 10¼ ins.
Height from rail to eaves (at center, cambered)	12 ft. 1⅛ ins.
Height from rail to eaves (before cambering)	12 ft. ¼ in.
Height from rail to center of coupler (after cambering)	2 ft. 10½ ins.
Height from rail to center of coupler (before cambering)	2 ft. 10⅞ ins.
Center to center of trucks	26 ft. 1¾ ins.
Center to center of tie beams	7 ft.

There seems to be a doubt as to just what the important minimum clearances of the country are, but this will probably be thoroughly settled before the M. C. B. Convention next summer. In this case the trucks have straight top "arch bars" and the coupler shank passes through the end sill.

The sills are as follows: Two side sills, 4 by 10 ins.; 2 center sills, 5 by 10 ins.; 2 intermediate sills, 4 by 10 ins., and end sills 10 by 14 ins., with end sill caps of 4¼ by 10½-in. oak. The drawings show the dimensions of the other important timbers.

A 4¼ by 10½-in. white oak end sill cap is placed on top of the end sill and the end sill is cut out for the coupler chafing iron. Inside of the end sill cap is a 6 by 6 by ¾-in. angle sill brace, 9 ft. ¾ in. long, bolted to the longitudinal sills and to end grain piece, which is beveled at the top. The couplers have 5 by 7-in. shanks, and the draft gear, which is the Miner, is secured between the center sills. The draft arms butt against a substantial bracket on the body bolster, which extends upward 8½ ins. between the center sills. Chicago grain doors and roofs are fitted to these cars. They have Westinghouse brakes and cast-steel bolsters and National hollow brake beams.

West Virginia University, Morgantown, W. Va., has received from the Baltimore & Ohio R. R. a gift of a 38-ton passenger locomotive of the 10-wheel type for experimental purposes. The locomotive has been placed in the new mechanical building, and will be mounted in a locomotive testing plant when the other equipment of the new laboratory is installed.

NEW LOCOMOTIVE SHOPS.

Central Railroad of New Jersey.

At Elizabethport, N. J.

A ground plan and details of the construction of the buildings of this plant were presented on page 340 of the 1901 volume of this journal. We now give a description of the equipment of the locomotive shops, which were built to maintain 450 locomotives. When the car shops are completed 8,000 coal cars, 8,000 other freight cars and 500 passenger cars will also be maintained here, and the present power house will serve for both departments.

Locomotive Shop.

This building is 150 by 700 ft. in size, and combines in three bays under one roof the erecting, machine and boiler shops. The erecting shop is 82 by 700 ft., with three longitudinal tracks and pits, arranged in three lengths, as shown in the plan. The pit nearest the machines is the shortest. This was done to avoid cutting up the floor for the entire length of the shop on all three tracks. Three lines of engines may be accommodated on the tracks and perhaps others on trestles between, the spacing of the tracks being 22 ft. from center to center. For vise work, very strong portable benches are used. They are not bolted down, and may be moved anywhere by the cranes. In dotted lines the main pipe tunnel is indicated in the plan. This extends the full length of the shop between the machine and erecting floors, with branches to the power house and blacksmith shop. The tunnels are 4 ft. wide and 5 ft. deep, of concrete construction.

The erecting shop is spanned by two 80-ft. 50- ton cranes, with 35-ft. clearance under the hooks. Two 35-ft. bays provide for the machinery. In the central bay all the heavier machinery is placed where it is served by a 10-ton and a 5-ton traveling crane. The lighter tools in the outer bay are served by hand cranes where these are necessary. A large monitor over the erecting floor and about half the areas of the two sides, of translucent fabric, furnishes natural light through the roof. The rest of the roof is of 3-in. yellow pine, covered with tarred gravel. The floor of this building begins with a 12-in. layer of cinders covered by 6 ins. of concrete, supporting 4 by 4-in. sleepers at 2-ft. centers, the spaces between which are filled with concrete, and these take flooring of 3 by 3-in. yellow pine.

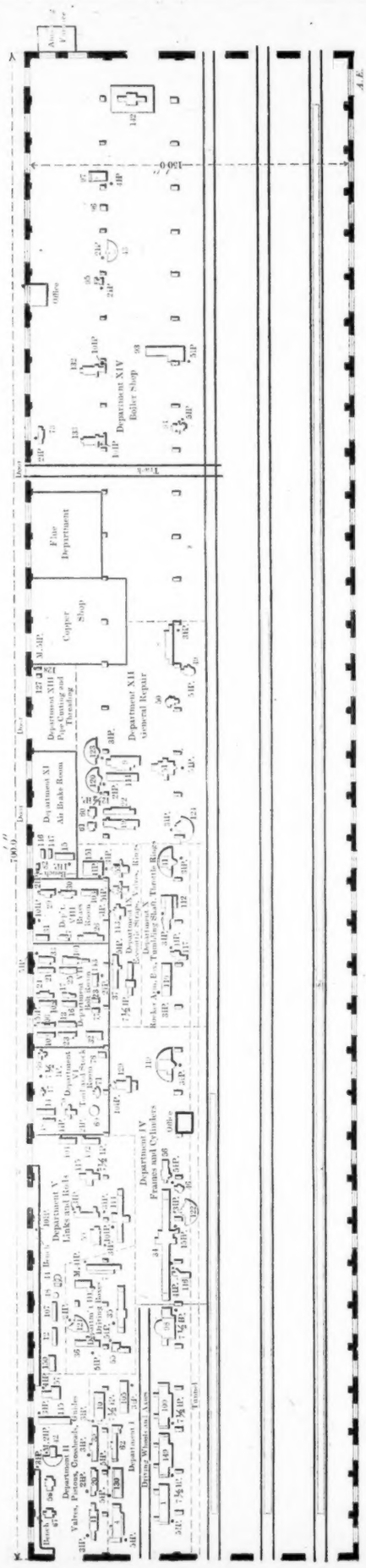
The machine tools are grouped in accordance with the work, with a view of economy in the transfer of material and parts. In the large plan drawing the motors are located and the sizes noted. An unusually large number of individual motors are used, and the number of group drives is correspondingly small. There are 18 group drives and about 70 individual motors, all on direct-current with rheostatic control. The "floating" tools have no foundations, they carry their own motors, and connections to the mains may be made at any desired location by plugs. About ⅝ of the motors are belted to the machines and the rest drive through rawhide pinions.

The boiler shop is equipped with oil furnaces, and a large annealing furnace outside of the building. The riveters are all operated by compressed air, the largest having a 16-ft. gap. A special 40-ton electric crane serves this riveter and provides 45 ft. clear space under the crane. The riveting tower covers a nearly square space at the end of the boiler shop, taking in two posts from the end wall and extending across the full width of the main machine bay.

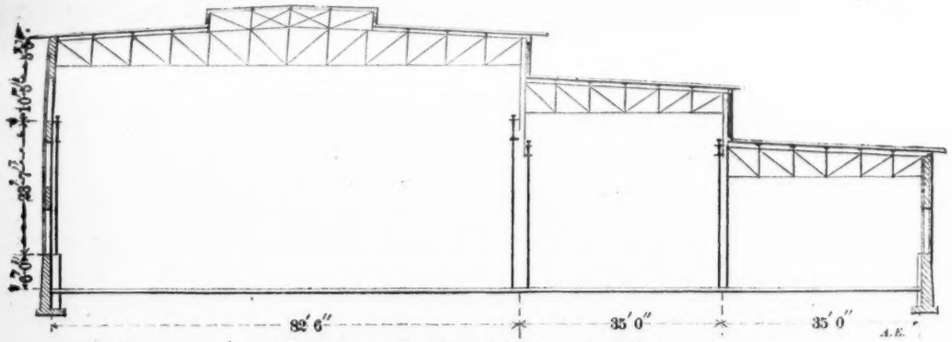
The heating system uses exhaust or live steam, the fans taking air from the building and after passing it through the heaters delivers it to concrete tunnels under the floor. These extend along the outside walls, the discharge being through galvanized outlets 10 ft. from the floor and 20 ft. apart.

Power House.

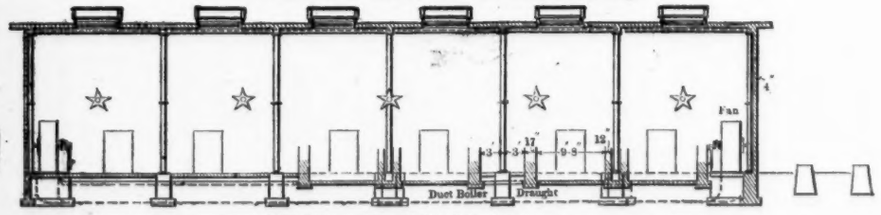
This building is entirely of concrete, including the roof. The power equipment consists of three 100-kw. direct-current generators at 240 volts, with spare spaces for three more. The



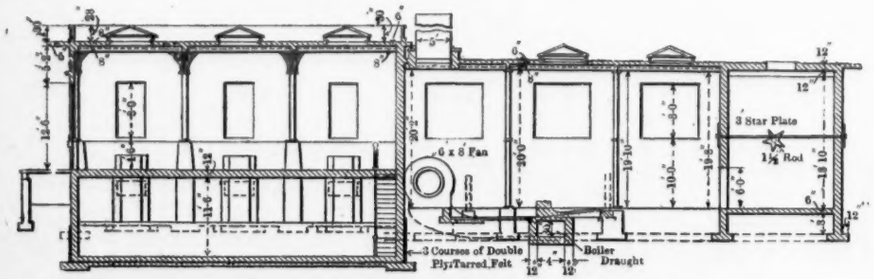
Plan of Locomotive Shop.
Central Railroad of New Jersey—At Elizabethport, N. J.



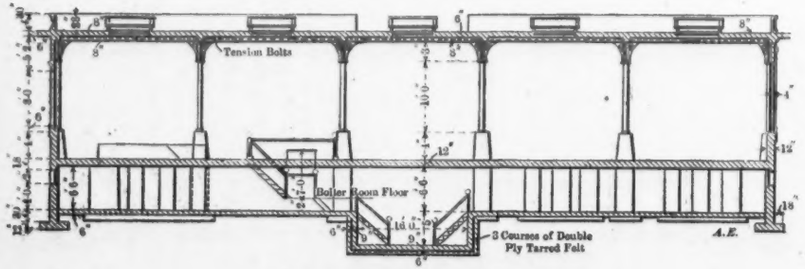
Transverse Section of Locomotive Shop.



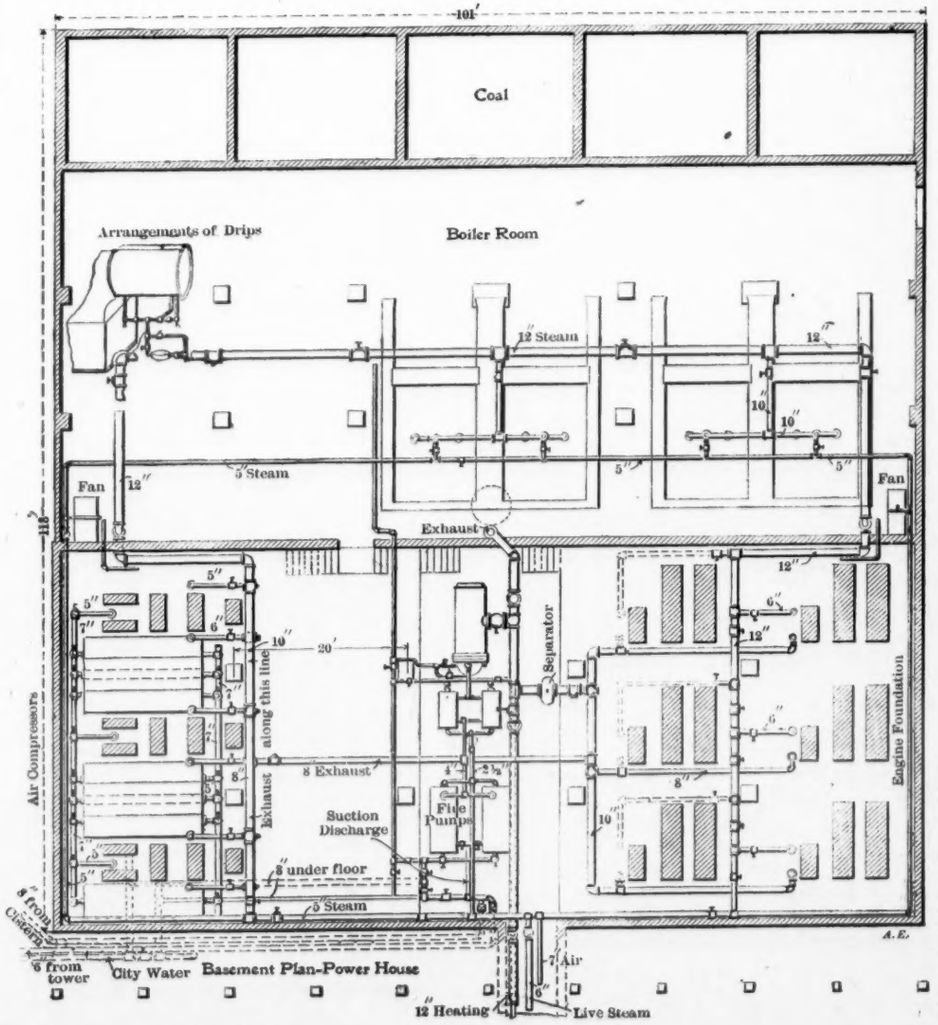
Boiler Room—Longitudinal Section



Transverse Section—Engine and Boiler Room



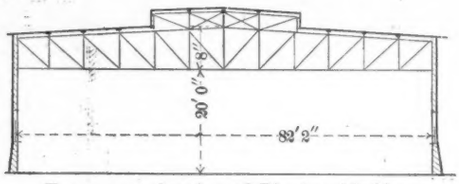
Engine Room—Longitudinal Section



Sections and Plan of Power House—Central Railroad of New Jersey.

McINTOSH, *Superintendent of Motive Power.* GEORGE HILL, *Architect* G. W. WILDIN, *Mechanical Engineer.*

generators are direct connected, of the Lundell-Sprague type, the generators being at a ratio of 30 per cent. of the power of the motors. No deduction is made for the crane or fan loads and the lighting load is figured separately. The engines are by Ball & Wood, with 16 by 16-in. cylinders, of 175 horse-power and running at 275 revolutions with a steam pressure of 100 lbs. Three engines are installed and spaces are provided for three more. They are placed on the foundations at the right in the power house plan. The engines have frames which would normally be used with 18 by 18-in. cylinders, and other parts in proportion. This strength was provided to deal safely with the peak of the load if two cranes are used simultaneously in addition to the other loads, and to do this with a cut-off of 5/8 of the stroke of the engines. With this method



Transverse Section of Blacksmith Shop.

it is easy to increase the power of the engines by using larger cylinders.

There are two 500 h.-p. standard Babcock & Wilcox boilers, with space for one more. They are operated by forced draft on the closed ashpit system, with a sheet-iron stack 5 ft. in diameter and only 25 ft. high. The draft is supplied through an underground duct. Rice coal will be used. It will be dumped into bins of about 300 tons capacity at the end of the power house, discharging into the boiler room. A conveyor will handle the coal.

The switchboard has three generator panels, one for lighting and one for power circuits. Circuit breakers are provided for all circuits carrying 200 amperes or more, the others having fuses. The limit of circuit in the entire switchboard construction is 750 amperes per square inch of section, rolled copper being used exclusively for bus-bars and switches. A recording wattmeter is supplied to each generator.

The piping is arranged as indicated in the engravings of the power house, the boiler header being a 12-in. pipe running into the engine room on both sides. The exhaust is piped through a 4 by 6-ft. tunnel to the locomotive shop for heating, the main pipe being 12 ins. Through the tunnel there is also a 6-in. high-pressure pipe for boiler testing and steam hammers. In the basement of the power house the piping is supported on pipe stands and the wiring is attached to the ceiling, which leaves the floor of the engine room free from obstruction.

The two air compressors, made by the Ingersoll-Sergeant Company, have a combined capacity of 2,000 cu. ft. of free air per minute. They discharge into storage tanks, and are of the single stage type. Along the air pipe six 4 by 12-ft. tanks are used to equalize the air pressure and save the expense of larger mains. There are three mains extending the whole length of the shop, and in addition a 2-in. main the full length of the middle pit.

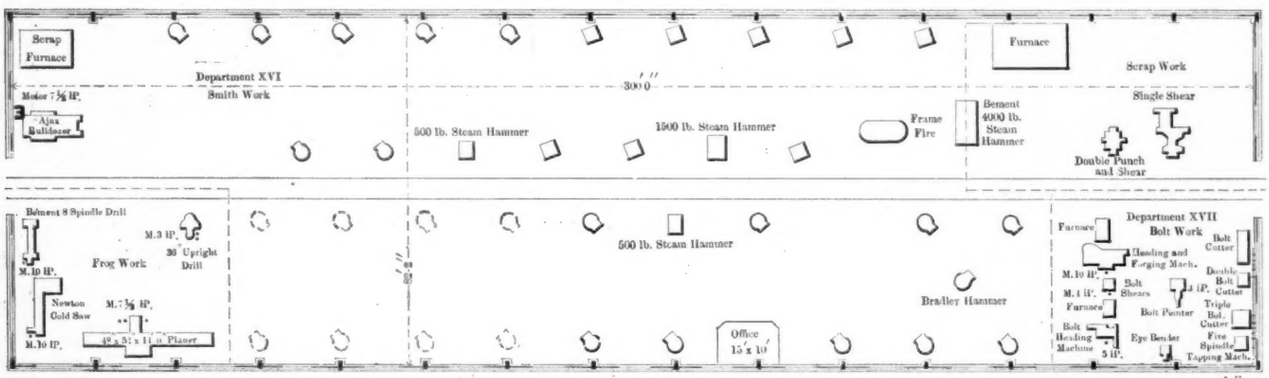
The cranes are given important duty in this plant, in fact, the machinery arrangement is hinged on getting everything to the cranes for movement to any desired part of the shop. Auxiliary hoists are provided, and the large cranes have a clearance of 35 ft. under the hooks, while the smaller ones have 25 ft.

Blacksmith Shop.

This building is 82 by 300 ft. in size, and has a reserve capacity for the car works, which must be provided for later. Its equipment is stated in the list of tools, and a glance at the floor plan shows that it includes a forge, a scrap, a bolt and a frog shop. A track runs through this shop lengthwise and connects with the yard through the transfer table. In the drawing two sizes of forges are indicated.

Other Features.

Transfer Table.—This table is 80 ft. wide, and the complete runway will be 800 ft. long. The speed will be 125 ft. per minute when fully loaded and 275 ft. when light. It will be used for the locomotive and car departments, and owing to the plan of the plant, will be a vital feature of its operation. We do not know of a larger table than this. Its capacity is 200 tons and it is carried on 16 wheels on eight tracks laid on 18-in. concrete walls, which rest on concrete foundations 18 ins. thick and 5 ft. wide, with expanded metal in their bases. Power is supplied to two 25 h.-p. direct-current motors by a trolley at one end of the table. Locomotives and cars will be warped on and off of the table by winding drums.



Blacksmith Shop—Central Railroad of New Jersey.

Steel baskets, adapted for handling by the cranes, will be used for transportating, cleaning and storing the parts removed from engines. These may be placed bodily in the cleaning vat and the parts kept in them until wanted. For communication with the tool room a pneumatic tube service will be installed. Tools will be ordered by numbers and will be kept in good condition in the tool room. Expanded metal lockers for the men will be placed in convenient locations.

The machine tools were furnished by Messrs. Manning, Maxwell & Moore.

For convenience in reference they are listed in the various subdivisions of the shops as follows:

List of Machinery in Detail.

Department I.—Wheels and Axles.

No. 1, 72-in. tire lathe; No. 149, 90-in. wheel lathe; No. 100, 90-in. wheel lathe; No. 48, 8-ft. boring mill, with slotter; No. 4, Niles tire lathe; No. 130, quartering machine; No. 62, 84-in. wheel press; No. 10, 30-in. by 12-ft. lathe; No. 105, 42-in. by 14-ft. lathe.

Department II.—Valves, Pistons, Crossheads, Guides.

No. 67, No. 1 cotter drilling machine; No. 58, 8-in. slotter;

No. 42, 48-in. radical drill; No. 145, Brown & Sharpe surface grinder; No. 57, 14-in. slotter; No. 11, 24-in. by 16-ft. lathe; No. 20, 28-in. by 12-ft. lathe; No. 39, 24-in. by 24-in. by 8-ft. planer.

Department III.—Driving Boxes.

No. 36, 24-in. by 24-in. by 6-ft. planer; No. 121, 30-in. drill press; No. 65, small hydraulic press; No. 40, 24-in. crank planer; No. 55, 36-in. car-wheel borer; No. 35, 36-in. by 36-in. by 10-ft. Pond planer; No. 7, 36-in. by 16-ft. engine lathe.

Department IV.—Frames and Cylinders.

No. 34, 60-in. by 60-in. by 25-ft. Pond planer; No. 116, 24-in. crank planer; No. 122, 40-in. drill press; No. 46, 36-in. upright radial drill; No. 56, cylinder boring machine; No. 129, 24-in. slotter; No. 119, No. 3 Bickford radial drill.

Department V.—Links and Rods.

No. 150, 12-in. by 42-in. grinder; No. 12, 18-in. by 8-ft. lathe; No. 107, 18-in. by 8-ft. engine lathe; No. 48, 4-ft. spindle cotter drill; No. 44, 40-in. upright drill; No. 59, 16-in. traveling head shaper; No. 114, slab milling machine for boring; No. 115, vertical milling machine; No. 102, 36-in. turret lathe; No. 104, Gisholt turret lathe.

Department VI.—Tool and Stock Room.

No. 18, 14-in. by 5-ft. tool room lathe; No. 14, 18-in. by 8-ft. lathe; No. 47, 13-in. friction drill; No. 66, tool grinder; No. 70, No. 2 universal milling machine; No. 69, Cincinnati cutter and reamer grinder; No. 71, Washburn twist drill grinder; No. 76, nut facing machine.

Department VII.—Bolt Room.

No. 109, 18-in. by 8-ft. engine lathe; No. 106, 18-in. by 8-ft. engine lathe; No. 108, 18-in. by 8-ft. engine lathe; No. 24, 20-in. by 8-ft. lathe; No. 21, 20-in. by 10-ft. lathe; No. 33, No. 2 lathe; No. 23, 22-in. by 8-ft. lathe; No. 13, 18-in. by 8-ft. lathe; No. 16, 16-in. by 6-ft. lathe; No. 17, 16-in. by 6-ft. lathe; No. 25, 16-in. by 8-ft. lathe; No. 101, 2 by 24-in. flat turret lathe; No. 32, universal lathe; No. 77, bolt centering machine; No. 143, 1-in. triple Acme bolt cutter; No. 28, 16-in. by 4-ft. Fairbanks lathe.

Department VIII.—Brass Room.

No. 31, 16-in. by 6-ft. Monitor brass lathe; No. 29, No. 3 Monitor brass lathe; No. 27, 12-in. by 5-ft. universal speed lathe; No. 30, No. 3 Monitor brass lathe; No. 26, 24-in. by 12-ft. lathe; No. 103, 18-in. Fox lathe.

Department IX.—Eccentric Straps, Valves and Rings.

No. 37, 24-in. by 24-in. by 8-ft. planer; No. 118, 36-in. by 36-in. by 10-ft. planer; No. 113, 34-in. vertical boring mill; No. 52, 39-in. boring mill; No. 53, 39-in. boring mill.

Department X.—Rocker Arms, Boxes, Tumbling Shafts, Throttle Valves.

No. 110, 42-in. by 14-ft. engine lathe; No. 117, 24-in. crank planer; No. 112, horizontal boring machine; No. 41, No. 3 Bickford radial drill.

Department XI.—Air Brake Room.

No. 82, angle-cock grinding machine; No. 146, 20-in. wheel and lever feed drill; No. 147, 20-in. wheel and lever feed drill; No. 15, 18-in. by 8-ft. lathe.

Department XII.—General Repairs.

No. 61, 8-in. shaper; No. 60, 16-in. shaper; No. 19, 36-in. by 16-ft. lathe; No. 22, 25-in. by 14-ft. lathe; No. 120, 30-in. drill press; No. 123, 40-in. drill press; No. 111, 42-in. by 16-ft. engine lathe; No. 9, 30-in. by 14-ft. lathe; No. 51, 80-in. boring mill; No. 50, 48-in. drill press; No. 49, 48-in. drill press; No. 8, 33-in. by 18-ft. lathe; No. 124, 40-in. drill press.

Department XIII.—Pipe Cutting and Threading.

No. 127, pipe threading machine; No. 128, Curtis pipe threading machine.

Department XIV.—Boiler Shop.

No. 73, 1½-in. Acme single bolt cutter; No. 133, 54-in. throat single punch; No. 132, 54-in. throat single punch; No. 95, small punch; No. 43, 42-in. radial drill; No. 96, suspended drill; No. 97, flange punch; No. 94, double punch and shear; No. 93, 10-ft. boiler rolls; No. 142, 16-ft. pneumatic riveter.

This machine list includes six "floating" tools, so-called because they are intended for moving about by the cranes to meet special demands in any of the departments. These are 24-in. crank planers with 4-h.-p. motors and 40-in. drill presses with 3-h.-p. motors.

In the plan of the blacksmith, frog, scrap and bolt shops the machines are all indicated, rendering the numbering unnecessary. These machines are as follows: Ajax bulldozer, two 500-lb. steam hammers, one 1,500-lb. steam hammer, one Bradley hammer, one Bement 4,000-lb. steam hammer, Bement 8-spindle drill, Newton coid saw, 48 by 54-in. by 14-ft. frog planer, 36-in. upright drill, a single shear for scrap, a double shear, three bolt cutters, a 5-spindle tapping machine, an eye bender, bolt pointer, heading and forging machine, bolt shears and bolt-heading machine.

For the drawings and information concerning these shops we are indebted to Mr. Wm. McIntosh, Superintendent of Motive Power of the road, and to Mr. George Hill, Architect and Engineer, who designed and constructed the plant.

TESTS ON CENTER PLATES AND SIDE BEARINGS.

In discussing center plate friction before the Western Railway Club recently, the results of tests made by Mr. L. H. Turner, Superintendent of Motive Power of the Pittsburgh & Lake Erie, were quoted. The object was to determine the relative amounts of friction in a ball-bearing center plate and side bearing, as compared with flat plates and bearings now commonly used in freight car service. The ball-bearing plates and side bearings were made of malleable iron. In the truck center plate were four pockets, the center line of which was a circle 6 or 6½ ins. in diameter. The pockets were ¼ in. deep at the center and tapered out to nothing at the ends. In each pocket was a 2¼-in. steel ball. The body center plate had a continuous groove ¼ in. deep, the center line being a circle of the same diameter as that on which the pockets were spaced in the truck center plate. The truck side bearing contained a pocket 15 ins. long, ¼ in. deep in the center, and tapering to nothing at the ends. In each truck side bearing was a 2¼-in. steel ball. The body side bearing contained a groove similar to that of the body center plate.

This arrangement was applied to a 60,000-pound flat bottom gondola car in June, 1897. In the latter part of October, 1900, after having been in service practically 3½ years, this car was brought to the shops and the trucks were removed. A very close examination was made of the trucks, and it was impossible to see that any wear had taken place in the flanges of the wheels; they were apparently as good as the day the wheels were placed in service. During this service the car had made a mileage of 11,323 miles and carried 226,440 tons.

These results proving satisfactory, it was then determined to ascertain, if possible, what decrease in friction was due to this arrangement over that in the ordinary flat plates. A turntable, 7 ft. long, was constructed, and one end of this car loaded to its maximum capacity was run on to it. By means of a spring dynamometer it was easy to determine the number of pounds necessary to deflect the truck. The tests gave the following results:

First Test.

Plain center plates and side bearings, with ⅛-in. deflection of the body bolster resting on the truck side bearings. Pounds pull necessary to deflect the truck	800 lbs.	100%

Second Test.

Plain center plates, without side bearings. Pounds pull to deflect the truck	275 lbs.	34%

Third Test.

Ball-bearing center plates, and side bearings with ⅛-in. deflection of body bolster resting on the truck side bearings. Pounds pull to deflect truck	75 lbs.	9%

Fourth Test

Ball-bearing center plates and without side bearings. Pounds pull to deflect truck	75 lbs.	9%

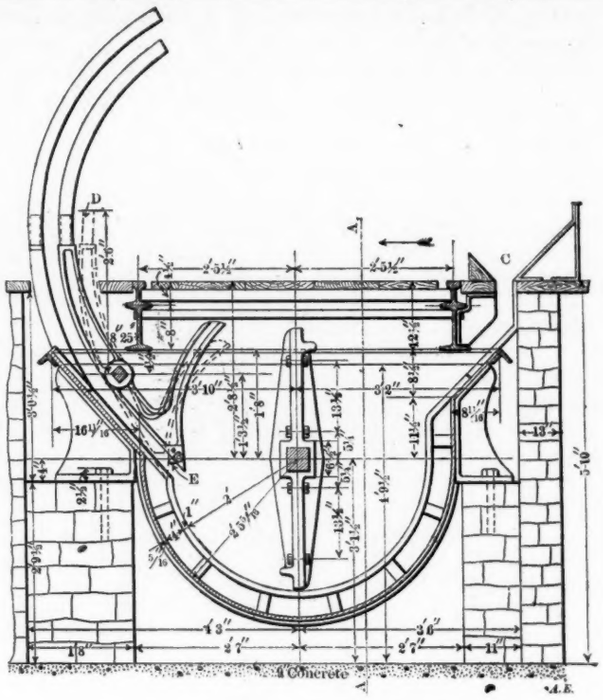
Since this experiment was made a number of all-steel gondolas of 95,000 lbs. capacity have been equipped with these bearings, and the results will be looked for with interest.

A NEW FLUE RATTLER.

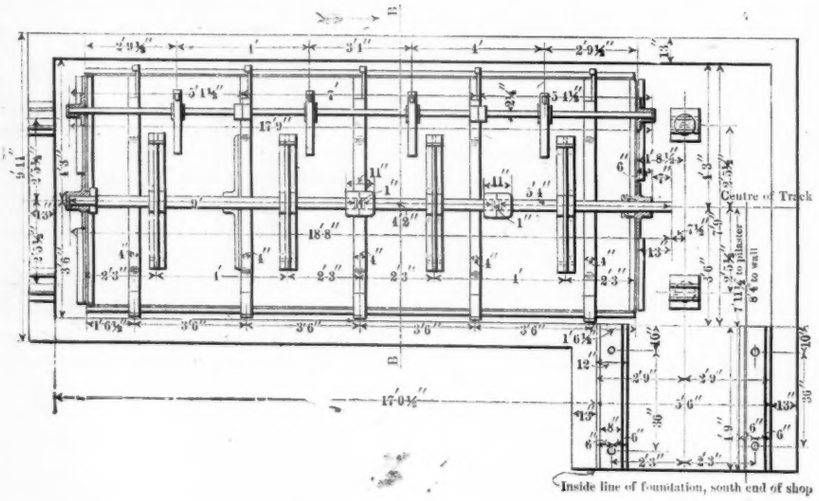
Chicago & Northwestern Railway.

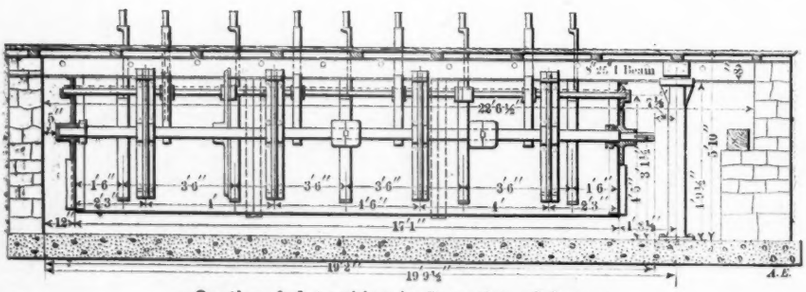
At the West Chicago shops of the Chicago & Northwestern Railway the boiler plant is equipped with a novel flue rattler which is giving excellent results. A shell of 5/16-in. tank steel is supported by castings in a masonry pit, which has an extension at one end for the link belt driving mechanism. Inside of this half cylindrical shell are five 1 by 4-in. rings supported by the shell on thimbles. These rings receive the fall of the tubes as they are lifted and dropped by four revolving arms. The shell is filled with water, which renders the rattler dustless, and when covered over by a plate roof the operation is also noiseless. These are great advantages over the usual forms of flue rattlers. The car carrying the tubes to be cleaned is received on the track over the rattler, the mechanism being sufficiently depressed to receive two tracks on a level with the ground. By pushing the tubes off at the right-hand side of the car, as shown in the sectional view, the tubes fall into the rattler at C, and the operation of cleaning begins. The guides, D, are closed, as shown in the dotted position, while the work is being done. After three or four hours, during which the machine requires no attention, the guides, D, are turned on their pivots and an opening is made whereby the lower layer of tubes is carried out of the machine at the left-hand side. Pawls or latches, shown at E, hold the last tube, and the process of unloading the machine is completed by a few turns of the arms. By the curved arms the discharged tubes are loaded upon the car, except a few at the last, which are taken out of the guides by hand. By turning the guides through 180 degs. on the squared positions at D, the tubes may be discharged to another car on a second track at the left-hand side of the machine if desired. The machine holds 200 tubes, and at the present rate of working, about 6,000 tubes per month are cleaned while operating but two-thirds of the time. In addition to cleaning the outside of the tubes the soot is thoroughly removed from the inside, and the attendant also attends to all the testing of the tubes. A speed of about 10 revolutions per minute seems to be most satisfactory. Tubes of 1½ to 1¾ ins. in diameter may be put through this rattler. The wear from the tubes comes upon the rings already mentioned.

This machine was designed and patented by Mr. H. O. Westmark, draftsman in the motive power department of the Chicago & Northwestern Railway at Chicago. In the Chicago & Northwestern shops the tubes are lifted out of the rattler by the traveling crane, which is the most convenient method there, because the rattler is located inside the shop.



Section B-B Looking in Direction of Arrow.





Section A-A Looking in Direction of Arrow,
A New Flue Rattler—Chicago & Northwestern Railway.

A pneumatic tube system for delivering parcels is in successful operation in Boston. From the main station at Essex street and Harrison avenue, in the retail store district, parcels are sent 1½ miles to the "Back Bay" station and one mile to the "South End." There are two lines of common cast-iron pipe 10-in. in diameter. These are not bored out, but the joints are carefully smoothed and laid like water pipe. The carriers run on five small wheels at each end which have stood service tests of more than 8,000 miles. With this construction no packing is required, and this is the greatest improvement embodied in this application. Very simple transmitters and receivers are used and a pressure of 2 lbs. per square inch is sufficient to give a speed of 30 miles per hour. Air power is supplied by a motor-driven 24 by 12 in. Rand compressor. From the description in "Engineering News" of December 5, 1901, this appears to be a distinct advance over previous pneumatic transmission methods.

TONNAGE RATING ON RAILWAYS.

Methods of the Canadian Pacific Railway.

Use of the Dynamometer Car.

By J. W. Harkom, M. Can. Soc. C. E.

Much attention has been given of late to the rating of locomotives by tonnage, with greater or less advantage. At the January meeting, 1901, of the New York Railway Club, Mr. Tait, of the Canadian Pacific Railway, read a paper on the subject and gave illustrations of the system established by him, which resulted most satisfactorily, increasing the average train loads and eliminating to a very great extent trouble by trains stalling, and also affording a basis for checking and comparing on an equivalent basis the performance on different divisions for the same and corresponding periods. This system has been thought by some to be elaborate and cumbersome, but when it is stated that no additional labor was found necessary and no extra delay was caused in preparing the trains for despatch from terminals, it will be seen that the advantages above mentioned were valuable aids to efficient service.

Rating Locomotives.—The system, as far as the car handling is concerned, was fully dealt with in the paper by Mr. Tait, but the classification of locomotives was not treated. In considering the advantages to be derived from a system of tonnage rating it was at once seen that a correct comparative rating of the locomotives must be first established. This was done first on a theoretical basis and loads set, the results causing further investigation to be determined upon and frequent practical tests were made, their results being compared with the theoretical power, which latter was calculated by the formula of the Master Mechanics' Association. Comparisons were made with the weight on driving wheels, with the result that while in various builds of locomotives of the same class the theoretical power was frequently at variance with practical results, the weight on drivers nearly always bore a constant relation to the results of the tests. These tests were made with a dynamometer car fitted with coiled springs, which repeated calibration showed to be extremely accurate, and the record, automatically made, showed speed and drawbar pull, together, affording a ready means of arriving at conclusions.

To any about to enter on work preliminary to establishing such a system, it is suggested that the locomotives be classified for freight service altogether by the power exerted on the drawbar behind the tender, leaving out entirely all calculations as to the work done by the locomotive to move itself, that being for practical purposes no advantage to the operating department. It will be conceded by everybody that the load a locomotive can haul is its measure of value to its owners, and the greatest load which it can steadily haul past a certain point at a defined speed is that measure.

In classifying the locomotives a piece of track embodying in its features those of the maximum grade and curvature should, if possible, be selected and the minimum speed at which the traffic is desired to be moved decided upon, and representatives of every class of locomotive should be tested there. Having done this, the dynamometer record of drawbar pull at the speed at which it is desired shall be the minimum when passing selected points will give the data for rating.

As a basis of comparison of power of locomotives, a unit of 1,000 lbs. pull on the drawbar at the minimum desired speed should be established, and it is suggested that, say on a 7, 10, 15 or 20-mile basis, a locomotive that will exert 1,000 lbs. on the drawbar shall be rated as of 5 per cent. capacity, so that 20,000 lbs. shall be 100 per cent., thus admitting all present classes of locomotives being rated with, say, 5 per cent. variation, and that is the basis on which they should be purchased and sold. There are many locomotives which can start a big train, but whose boiler capacity will not allow them to sustain the effort. Again, there are others which are cylindered altogether above the efficient work to be got by the weight on drivers with more or less efficient boilers.

The system of classifying by drawbar pull eliminates all arguments as to merits of this or that make or style. When it is remembered that whether the motive power be steam or electricity the tractive power is limited by the weight on drivers, but is also dependent on two other factors, viz.: Machinery power, varied by size of cylinders, driving wheels, etc., and boiler power to supply the machinery, and the weakest engine fixing the power, it must be clear that measurement by drawbar pull is the best basis for classification, it being capable of direct and definite determination. The result would then be shown in an index giving the numbers of all locomotives and their capacity, and the heading of haulage tables would correspond to the capacities of the various locomotives in service on the section for which table is compiled.

Fixing Loads.—Having fixed the relative capacities of locomotives, next comes the determination of loads on each district. The use of an ordinary profile to determine the load a locomotive should haul over any section is an unsatisfactory method, and the value of momentum of the train, which is sometimes calculated very elaborately, is under no method so clearly shown as by a dynamometer car recording drawbar pull and speed together, as by it, taking advantage of the momentum where practicable, the "virtual" grade is arrived at.

In reading these records marginal notes, made at the time the record is made, should be taken to avoid errors, as for instance, in case of a train passing over a sharply defined summit of a grade in, say, a rock cut, the locomotive having passed the summit will suddenly exert an increased and unnecessary power which will be recorded; therefore, the exact points of summits and bottoms of grades, also commencement and end of curves, should be carefully noted, in order that incorrect deductions may be avoided.

It is not advisable to depend on one trip over a section to fix a load, but after noting results with one load additions or reductions should be made on another train, the dynamometer recording whether the locomotive is exerting its proper power and the correct speed is maintained.

Equivalent System to Meet Varying Classes of Tonnage.—All the above is correct for any constant class of traffic where cars are of the same character and weight, and similarly loaded, but when trains are made up, as in the case on most railroads of varying classes of cars and freight, then there comes into prominence the necessity of some system which will afford a means of making up the trains so that the locomotives may in their several capacities be loaded fairly and give the best average results in time and fuel used on each trip.

To illustrate the difference in power required to move the same actual tonnage in similar cars with different classes of freight we will assume a train of 40 box cars weighing 30,000 lbs. each, loaded to their full capacity of 60,000 lbs. with grain, making a total weight of 1,800 tons, or 45 tons per car gross weight, which it is found is just the load a locomotive exerting its full power can take past a certain point at a defined speed. Then assume the same class and build of cars loaded with hay, the weight in each car being only 20,000 lbs., or 25 tons per car, gross weight. To get 1,800 tons actual weight of train will require 72 cars. These trains are of the same actual weight, yet it takes a practical railroad man no time to determine that the 72-car train is too heavy for the locomotive which can just haul the 40-car train under the conditions specified.

It is clear, therefore, that if the tonnage load is fixed by the heavily loaded cars the other train would stall and embarrass the traffic, or, if fixed by the tonnage that the lightly loaded car train can haul there would be a loss in case of the heavily loaded cars. To leave the loading to the discretion of employees or officials, whether trainmen or yardmasters, would result in confusion. Somewhat similar objections present themselves when trains are made up by cars instead of tonnage.

Canadian Pacific Method.—There have been many attempts

to arrive at a system by which trains may, under the varying conditions noted above, be made up to get the best results, but that which the Canadian Pacific Railway has adopted and styled the "Equivalent," is the one best adapted for universal use. The term Equivalent signifies that each train is made up of tonnage equal to a fixed schedule and the basis on which it is founded is that of the tonnage of cars loaded with two tons of freight to one ton of cars.

The next thing to note is that compared with a "two to one" car, an empty car pulls, per ton, much harder. Under certain conditions a ton of empties will pull 30 per cent. harder than a ton of "two to one" loads, and an empty car train of 1,800 tons would pull equal to 2,340 tons of such cars as the 40-car train of 1,800 tons above referred to.

It will be at once remarked, "But that 30 per cent. is not true for all conditions." That is quite true, but it is very peculiar how nearly 30 per cent. averages correctly on roads with grades between 0.5 and 1 per cent. Careful tests made go to show that on level track empty cars pull per ton as high as 70 per cent. harder than loaded of "two to one," while on grades as high as 1.67 per cent. the difference on straight track comes down to 16 per cent. But here comes again trouble, for there are few grades without curves, and these will generally be found very near the summit, and always are the hardest places to get a train past. On a 2° curve on 1.67 per cent. grade the increased power required per ton to move empties compared with "two to one" loads comes up to 22 per cent. It is the uncertainties which curvature and grades in their every-day occurrence infuse into theoretical calculations which makes the use of a dynamometer car the best method of determining a load for locomotives.

Many persons have noted that cars with pressed steel trucks pull harder than those of older construction. The writer found on 0.5 per cent. straight track empty cars with pressed steel trucks pulled 36 per cent. harder than the same cars loaded "two to one," while with ordinary cars under the same conditions the difference was 30 per cent. On 1 per cent. straight tracks the difference with ordinary cars was 26 per cent., and on 1 per cent with 3 degree reverse curve, 38 per cent. These instances are given to show how closely a 30 per cent. equivalent will average on grades between 0.5 per cent. and 1 per cent. under average conditions.

The Canadian Pacific Railway has lately put into force on various sections 10 per cent. and 20 per cent. equivalents to meet the varying conditions of grades, the result being satisfactory, the 20 per cent. having been used on grades of from 1 per cent. to, but not including 2 per cent. and the 10 per cent. equivalent on grades of 2 per cent. and over. Using different equivalents will offer no difficulty, as all that has to be done in making up trains is to use the desired chart, a specimen of which is contained in the Proceedings of the New York Railway Club of January, 1901.

The total quantity of coal taken in any given year from the mines of the whole world cannot be very accurately ascertained, but from the best available information, according to "Cassier's Magazine," it may be assumed to have been about 700,000,000 tons of 2,000 lbs. each for the year 1900, the last of the nineteenth century. Assuming that the combustion of 1 lb. of coal produces available energy equal to the work of one horse for one hour, and that a horse-power is equal to the power of seven men, it is found that this represents in energy the equivalent of 9,800,000,000,000 hours of work for one man, and allowing 10 hours to each day and 300 working days to the year, this is found to be equal to the work of 3,000 millions of men during one year. This is about double the entire population of the globe, and it follows that the utilization of the energy of combustion is equivalent to an increase of the working capacity of this population to the extent of an addition of two able-bodied men for every man, woman and child; and practically it amounts to much more than this, for these additional 3,000 million stalwart laborers make no demands upon the food products of the world; they need no clothing, no matter what the zone of their employment, and in faithfulness, loyalty, general docility and ease of management they are beyond compare.

INCREASING USE OF FUEL OIL, SOUTHERN PACIFIC RAILWAY.

Mr. Howard Stillman, Engineer of Tests of the Southern Pacific, outlined the use of oil on that road to a representative of the New York "Commercial" as follows:

The company has been gradually increasing its use of fuel oil for years. About the only new feature at present is the conversion of ferryboats on the bay of San Francisco from coal to oil burners. The Piedmont, which runs between San Francisco and Oakland, has used oil since November 1 with good results. The Solano, which ferries trains from Benecia to Port Costa, is being fitted for burning oil. As far back as 1885 oil was tried on this boat and it made a satisfactory fuel, but the oil used was a high distillate and costly, as compared with the present California fuel oils, which are not only cheap but perfectly safe.

The company has about eight ferryboats on the bay, and it is said that all will be converted into oil burners. There are about 170 locomotives on the Southern Pacific system using oil. Its use of oil for locomotives dates back half a dozen years and there has been a gradual increase of the number converted.

Recently the company bought five Baldwin engines with Vanderbilt fireboxes. They are in successful operation between Yuma and Los Angeles, burning oil. There are over 60 oil-burning engines running on Southern Pacific lines out of Los Angeles. None of the Sacramento locomotives are using oil. In the shops at Los Angeles, Tucson and West Oakland oil is being used in stationary boilers. In the Sacramento shops oil is used to a limited extent.

GRATE AREAS FOR LIGNITE.

In answer to a question concerning the burning of lignite in locomotive service, in a recent discussion before the New York Railroad Club, Mr. Vauclain, of the Baldwin Locomotive Works, made the following statement

The ratio of heating to grate surface for lignite coal depends somewhat on the analysis of the lignite itself. For the more inferior grades of lignite coal we like to have a ratio of not over 50 to 1, and preferably 40 to 1. 40 to 1 is a very desirable ratio of heating to grate surface for anthracite coal; but anthracite coal is entirely the opposite from lignite. Lignite is a free-burning fuel, very light and full of water, similar to green wood, and therefore, in addition to the excessive grate surface, it is necessary to provide excessive depth of furnace. For good bituminous coal, to get the very best results, we demonstrated several years ago, I think in 1892 or 1893, that the desired ratio of heating to grate surface was about 60 to 1, and in all the satisfactory locomotives for bituminous coals that we build the ratio of heating to grate surface is about that figure, unless it is found that in order to increase the weight of the locomotive we can increase the size of the boiler and get a much larger heating surface than is actually necessary for a locomotive of that sort, in which event the heating surface is allowed to run as high as 70 to 1. The "run-of-mine" coal is always harder to burn than the better class of coal, and for that purpose, when we know of locomotives that are to use that class of fuel we do not like to exceed a ratio of 1 to 60; whereas with the higher grade of bituminous 1 to 75 is quite permissible. For soft coal screenings or slack at the mines, we find that it is necessary to provide about all the grate we can get. That becomes a case of getting the most of a good thing that we can.

The German experiments upon high speeds upon the Prussian Military Railroad line have so far reached a maximum of 99.44 miles per hour with a line tension of 10,000 volts. This is believed to be the safe limit for the present track and it is to be reconstructed before pursuing the investigation further.

COMPOUND CONSOLIDATION PASSENGER LOCOMOTIVE.

Colorado Midland Railway.

Built by Baldwin Locomotive Works.

The chief interest in this locomotive is that it is of the consolidation type and used for passenger service on grades of 3 and 4 per cent. and curves of 16 degrees in the mountains of Colorado. These conditions required unusual tractive power and involved a large weight on driving wheels. M.. Vauclain, of the Baldwin Locomotive Works, in explaining the reason for the inclination of the cylinders of this engine, said that the officers of the road wanted the cylinders sufficiently high to clear the "scenery" of the Rocky Mountains, which is "so unstable that it is likely to be found alongside the railroad tracks." The cylinders were placed in this way to clear any ordinary boulders which may roll down. Flanges are placed on all of the driving wheels. These engines have been fitted with the form of cylinder brake illustrated on page 12 of our January number in connection with the recent heavy oil burning locomotives for the Santa Fe.

This design clearly illustrates some of the difficulties to be contended with in typical Rocky Mountain railroading. These engines are used principally between Colorado Springs and Divide, a distance of twenty-seven miles; and between Arkansas Junction and Thomasville, a distance of thirty-six miles. The maximum grade between Colorado Springs and Divide is 211.2 feet rise in one mile, while the average for the whole distance is 109.9 feet to the mile, which average is reduced considerably by the small average of 25.8 between Colorado Springs and Colorado City, a distance of three miles. Between Manitou and Cascade Canon, the maximum grade, there is an average of 189 feet rise to the mile, with seven 16°, four 14°, and a great many curves of less degrees in a distance of 5.4 miles, including six tunnels in a distance of 3.4 miles.

The time of train No. 5, west-bound (which consists of a combination mail and smoker, two chair cars and a sleeper, weighing approximately 150 tons, not including passengers, baggage and mail, and a tourist sleeper added to this train one day a week, which increases the light weight tonnage to 195) between Manitou and Cascade, is 29 minutes. There are a few cases recorded where one of these engines made the time with six cars, the light weight of the train being approximately 230 tons. Train No. 4, east-bound, has need of the compounds between Thomasville and Ivanhoe, where a maximum grade of 158.4 feet and an average of 132.7 feet rise in a mile exists, including in this distance of 21.4 miles about thirty-eight 16° and twenty 14° curves, not counting those curves of greater radius. The time for this stretch is 1 hr. 23 minutes. The train usually consists of a baggage car, combination smoker and mail, chair car and a sleeper, all but the combination car having 6-wheel trucks. The light-weight of the train is about 166 tons, and once a week this tonnage is increased to 215 tons by the addition of a tourist sleeper. These engines have a rigid wheel base of 15 ft. 9 ins., and have all tires flanged, which experiment has met on this road with the most satisfactory results as to their easy curving qualities and minimum flange wear, due to the fact that four flanges instead of two, as is customary, take the thrust of the sharp curves.

The most important dimensions of this engine are given in the following table:

COMPOUND CONSOLIDATION PASSENGER LOCOMOTIVE.
Colorado Midland Railway.

Cylinders.	
Diameter	high pressure, 17 ins.; low pressure, 28 ins.
Stroke	30 ins.
Valve	Balanced piston
Boiler.	
Diameter	74 ins.
Thickness of sheets	¾ in.
Working pressure	200 lbs.
Fuel	Soft coal
Firebox.	
Material	Steel
Length	120⅛ ins.
Width	42 ins.
Depth	front, 65¾ ins.; back, 61 ins.
Thickness of sheets, sides	5-16 in.
Thickness of sheets, back	⅜ in.
Thickness of sheets, crown	⅜ in.
Thickness of sheets, tube	½ in.
Tubes.	
Material	Iron
Number	337
Diameter	2 ins.
Length	14 ft.
Heating Surface.	
Firebox	172.2 sq. ft.
Tubes	2,453.7 sq. ft.
Total	2,625.9 sq. ft.
Grate area	35 sq. ft.
Driving Wheels.	
Diameter outside	60 ins.
Diameter of center	52 ins.
Journals	9 ins. by 11 ins.
Engine Truck Wheels.	
Diameter	30 ins.
Journals	6 ins. by 10 ins.
Wheel Base.	
Driving	15 ft. 9 ins.
Total, engine	24 ft. 4 ins.
Total, engine and tender	53 ft. 2 ins.
Weight.	
On drivers	157,500 lbs.
On truck	22,500 lbs.
Total, engine	180,000 lbs.
Total, engine and tender	300,000 lbs.
Tender.	
Diameter of wheels	33 ins.
Journals	5½ ins. by 10 ins.
Tank capacity	6,000 gals.
Service.	
Passenger.	
Grades, 4 per cent. combined with curves of 16 degrees.	

Compound Consolidation Passenger Locomotive—Colorado Midland Railway.

J. R. GROVES, *Superintendent of Machinery* BALDWIN LOCOMOTIVE WORKS, *Builders.*

(Established 1832.)

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Mr. Edward E. Silk, who for two years has been connected with this journal as Associate Editor, concludes his connection with it with the appearance of this issue, to accept a promising appointment with the O. M. Edwards Company, of Syracuse, N. Y. The readers of this journal will join us in regretting his retirement from this field and in wishing him and his new associates long life and prosperity.

"I have seen the steam gauge point up 25 lbs. in four minutes," writes a correspondent who is using oil fuel extensively on locomotives. Such forcing is impossible with coal and for the sake of the boilers it is well that it should be impossible. In burning oil the fire needs constant attention, as is required by coal, and if the change of the running conditions such as the speed, reverse lever and throttle positions are immediately followed by corresponding changes in the oil valve there need be no great variation in the steam pressure. While the fireman is relieved of his laborious work on an oil burner it seems to be difficult to get most men to keep close watch of the fire. Because the fire can be so easily forced the men do not feel the necessity for keeping constant pressure, and to this cause may be laid the only difficulties which appear to be serious in oil burning. Cases are known indicating that in a crown bolt the center of the head is curiously affected by the heat and raising the question whether it cannot even be melted, the metal in the center of the head being too far from the water to keep its temperature down below the danger point. With careful regulation there is no difficulty, but most firemen are not careful, and occasionally neglect the fire, having to force it to catch up again.

This points to the desirability of building boilers for oil burning which are specially adapted to severe forcing. To meet this condition staybolts should be avoided, and this appears to indicate a specially favorable field for the corrugated cylindrical firebox, which avoids the necessity for staybolts. At least the statement recently made in these columns with reference to the desirability of designing boilers specially for oil burning seems to be justified.

THE WIDE FIREBOX FOR SOFT COAL.

There is no uncertainty or hesitation in the expression of opinion concerning the moderately wide fireboxes for soft coal by those who are using them. Locomotive improvements so universally satisfactory as this are very rare. More time will be required to show the effect of short and wide fireboxes on the breakage of staybolts, but even in this direction considerable improvement over the narrow firebox, confined between the frames, is expected. Staybolt breakages appear to be exceedingly frequent in some of the large passenger engines with narrow grates, built two and three years ago. It is probable that the short and wide fireboxes will do better than these. The best advantage of the wide firebox is its steaming qualities, and the present exigencies of service make this feature prominent.

"What steam pressure do you carry?" used to be a common question. It has given place to "What steam pressure have you got?" The large grates help in a remarkable way to answer the second question favorably. There are men who do not expect to build another narrow-firebox locomotive of the old type for road work, so confident do they feel. On the Buffalo, Rochester & Pittsburgh, Mr. Turner has found it necessary to define the condition which was described on so many delay reports by the entry "no steam." Having engines with normal pressures varying from 140 to over 200 lbs., it was necessary to establish the pressure at which stalling with the normal rating would probably occur. He placed the condition of "no steam" at 85 per cent. of the boiler pressure. This reflects the rigor of the present-day requirements in a way to indicate the importance of adequate boiler power. The tendency in boilers seems to be to make them still larger. With steam heat, air brakes, air sanders and bell ringers, air fans in the cars, water raised by air in sleeping cars, electric headlights and electric lights in cars, larger boilers were needed for the demand for "auxiliaries," and the gradually increasing weights of trains add another important requirement to be met. The boiler cannot be made too powerful in these days, and the wide firebox has come in a time when it was greatly needed.

It cannot be said, however, that the wide firebox gives no trouble or that it always insures abundant steam. On at least four prominent roads wide fireboxes have given considerable trouble in failures to steam freely and in a serious leakage of flues. After investigation it can be stated that these difficulties arise from a very definite and simple cause. They have occurred with locomotives having long and also with short flues. There must be something about the wider grate that is not fully understood.

With grates of 28 sq. ft. area thick fires were necessary in order to burn a sufficient amount of coal, and, of course, the strong draft necessary for thick fires required rather small nozzles, but holes in the fires of these engines are rare and if they occur the engine "dies" at once. When the grate area is increased to 40 or 50 sq. ft. the fire is thinner, and, naturally, the nozzles were somewhat enlarged. Thin fires offer less resistance to the air and a hole in a thin fire does not produce a sudden effect. A thin fire needs more careful firing than a thick one, and for a wide firebox the thinner the fire the better, providing the necessary amount of coal is burned. It is the opinion of those best able to judge that the leaky tubes and failures in steaming of wide firebox engines are gen-

erally caused by the admission of cold air through holes in the fires which often occur unnoticed, and generally in the corners of the fireboxes. As one mechanical officer put it, "Our wide firebox engines never fail in steam since the firemen learned the 'side step' which is necessary to get the coal into the back corners."

A large grate requires more careful firing than a small one, but when properly handled the work of the fireman is easier with the large grates, and it is fair to expect greater care.

HEAVY LOCOMOTIVES.

Editorial Correspondence.

Where Is the Present Tendency Leading and Is It Justified?

There never was a time in the history of the locomotive when so many radical and so important steps in progress have been taken as during the past few years, and it is natural that this should raise the question as to where it will lead. Recently rumors were heard of a new design for special mountain service of a monster locomotive of the decapod type, with 230,000 lbs. on the driving wheels, a total weight of 260,000 lbs. It may also be mentioned that a prominent superintendent of motive power has expressed a favorable opinion of 20-ft. tubes for a prairie type passenger locomotive having 84-in. drivers.

If these suggestions are worked out in practice, very little surprise will be felt at anything which may follow. This heavy engine has already been built, and the very proper question as to where this is leading is worthy of thoughtful attention. Are these enormously heavy engines justified? They are if there is work for them to do and if the design is conducted on a logical and consistent plan. In this case 4,681 sq. ft. of heating surface and corresponding cylinder power are employed. On mountain roads with long, heavy grades there is undoubtedly work for such machines to do. In view of the unquestioned tendency toward heavier engines for all classes of service and the doubt in many minds of the advisability of such a tendency, it is worth while to review the arguments advanced in favor of heavy engines.

For years the policy of the Lake Shore, with its level and straight road and very light engines, was held as an example of economical practice, but now this road is among the foremost in the new order of things and of the wisdom of the change there can be no doubt. Even short roads with but little over 100 miles for the longest run, are taking up heavy locomotives and comparatively level lines are building larger ones, showing that the practice is by no means confined to roads having heavy grades. There must be a reason for this. These engines must be reducing operating costs by increasing the weights of trains. They certainly do not represent a spasmodic movement.

A reduction in the cost of train and engine crew wages is the first saving to attract attention as a result of increased weight of trains. It is perfectly clear that the heavier the trains to haul a given tonnage the less will be the wages of the men required to operate them. The saving is instantly apparent, and it bears a direct relation to the weights of the trains. Double-heading is more economical than to run short trains, but both are comparatively expensive. Other savings which, while also increased in the same way, are not so apparent and are not evident at all on roads which have not yet adopted the ton-mile basis for locomotive statistics, and where separate accounts of passenger and freight expenses are not kept.

This problem may be examined with reference to the effect of heavier engines on the cost of repairs, wages of crew, lubrication and waste, terminal service and fuel. Larger engines are sure to increase the cost of repairs per engine mile, but they should, if properly loaded, reduce the cost per ton mile, because of the increased tonnage hauled. The hauling capacity may increase more rapidly than the cost of repairs, providing they are given the tonnage which they require. Wages of engine men, and also train crews, depend upon the number of trains, and any influence tending to reduce the number of trains to haul a given tonnage must effect a corresponding saving in both of these items. In busy times this is an important economy. The cost of lubrication and waste will be about the same for large as for small engines when based upon ton miles, because as the tonnage increases so also do the number of bearings, and generally also the steam pressure. In terminal service there will be no material increase in the wages of "dispatchers" and "hostlers," and while the bearing surfaces are larger the cost of wiping should not increase much. In the roundhouse, laborers' wages will increase per engine mile, but they should decrease when based on the ton mile, and a saving may be expected here.

As to the fuel item, generalizations based upon the data taken from isolated cases of very large engines are unsatisfactory. We prefer to take the results of a gradual increase in the weight of locomotives on any road, and from the tendency shown in such a case, a fair judgment as to the advantages of continuing the process may be formed. In our November issue was printed a table of data from the large engines on the Illinois Central, the December number recorded tests on the Michigan Central, and we have also another confirmation of the policy of increasing the weight of engines, tending to show the value of a gradual increase, as follows:

We have been permitted to examine the records of three classes of locomotives on one of the leading railroads and to make a comparison which, while it does not include a so-called heavy engine, is sufficient to establish the tendency of the decreased cost obtained by two steps toward heavier locomotives. This comparison includes a large number of 18 by 24 eight-wheel and 19 by 24 ten-wheel and 19 by 26-in. ten-wheel engines. The results are taken from the actual records of freight service, and are believed to be reliable. These engines are represented by their tonnage capacity under the same conditions of speeds and grades. In the following table the cost of terminal service includes the wages of wipers, laborers and dispatchers, and the item of train crew wages is based on a cost of 7 cents per train mile.

Comparison of Three Classes of Locomotives of Different Capacities, Showing the Advantages of the Heavier Engines in Freight Service.

	10-wheel. 19 x 26"	10-wheel. 19 x 24"	8-wheel. 18 x 24"
Weight of engine, lbs	152,500	126,000	90,000
Weight on drivers, lbs	118,400	102,700	57,700
Tonnage hauled, average for each	620	460	390
Terminal wages per 1,000 ton-miles, cents	1.96	2.28	2.69
Locomotive men, wages per 1,000 ton-miles, cents	10.38	13.21	14.97
Train crew wages per 1,000 ton-miles, cents	11.18	14.23	17.70
Oil and waste per 1,000 ton-miles, cents	0.52	0.52	0.52
Repairs and stores per 1,000 ton-miles, cents	6.23	7.11	7.61
Fuel per 1,000 ton-miles at $1.50	145.80	185.30	200.60
Summary, based on 1,000 ton-miles	$1.76	$2.23	$2.44

While these are not very heavy engines, the effect of increased capacity is perfectly clear, and it is fair to expect the relationship to continue with much greater increase of capacity. In these three classes of locomotives the consumption of coal per 100 ton miles has decreased in the order of 26.75, 24.71 and 19.44 lbs. in favor of the heavier engines, and from more recent returns a modified class of the ten-wheel engines having wide fireboxes, show the last figure to be reduced to 15.5 lbs. per 100 ton miles. This is taken to indicate that heavier engines are desirable, where they may be properly loaded, and that wide fireboxes and other improvements should be included in designing them. There is much to be gained in increased weight and power, to which still more gain may be added by other improvements. It may, perhaps, be found that the heavier the engine, the greater the advantages of such improvements as wide fireboxes, but there is nothing to be gained by increased weight which does not give increased power.

At present the development of the locomotive is further advanced than that of the track, the strength of the draft gear of cars, the strength of bridges, the length of side tracks, and it is also in advance of operating methods in loading heavy engines. In the proceedings of the Central Railway Club for

September last the experience of the Illinois Central with its two heavy engines was stated by Mr. A. W. Sullivan, assistant Vice-President of that road. In speaking of the two very large engines on that road, referred to in the record printed in our November number, he said:

They were simple engines with cylinders 23 x 30; they carried 210 lbs. of steam, had 82-in. boilers, long fireboxes, one a consolidation, the other a twelve-wheel type. We were quite interested to know what this size of engine could do in the way of ultimate pulling capacity, so the order was given to start with a train of 1,500 tons on a run out of Chicago of about fifty miles, in the middle of which was the ruling grade of that district, about 24 ft. to the mile; and each day it made the trip increasing the train load by 500 tons until the train got up to 3,500 tons, eighty-two loaded cars. There was no trouble in the engine handling the train; the trouble was to handle the engine.

This was about two years ago. We had two engineers and three firemen; that is, we had these men in reserve, and when we came to the heavy part of the hill the engine in its hardest pull made a mile and a half to a ton of coal and used up 5,000 gallons of water in running five miles. When it arrived at the station at the summit of the grade it had to cross over to the other track to let an important passenger train pass it, necessitating a short back-up movement to enter the cross-over track. In making this back and forward movement the train broke in two eight or nine different times, on one occasion shearing under the head and under the nut twelve 1-in. drawbar pocket bolts, so great was the power of the engine. Two hours and three-quarters was consumed in crossing over and getting back, and the train that it was intended to let by without causing any delay was delayed an hour and a half.

We came to the conclusion that it was quite possible to get one engine that was large enough to handle a bigger train than was practicable, as a transportation proposition, to move over the road.

These large engines have now been in service nearly two years. We give them each trains of 1,800 tons on portions of the road where mogul engines of 19 x 26-inch cylinders handle trains of 900 tons. Each of the big engines takes a double train. The total expense of moving 10,000 tons one mile with the big engines is $1.86, as against $2.02 with the mogul. By reducing the train to a tonnage that could be handled readily, we have been able to operate the large engines successfully, having them take their turn in the service just as it comes—one day with a heavy coal train, next day with a stock train or with a banana train, making speeds anywhere up to forty-five to fifty miles an hour, and do that without any trouble.

This may be taken as a condemnation of the heavy engines, and it will doubtless be so interpreted, but is it not really the best proof that the principle of great power is correct and that serious weakness exists in the other directions? An advantage of 10 per cent. in operating these large engines, even when underloaded, is important, and the weak factors thus exposed should be studied. Doubtless it would be wiser to come to the 150-ton engine more gradually, but there is good reason to believe that we shall come to it before long. Another fact drawn from the Illinois Central experience is the importance of using the utmost care in the design of the large engines to secure every possible advantage from the increase of weight. In locomotives and cars the most important work for the next few years will be in securing operating advantages from every possible pound of weight. The boiler of the locomotive should profit by every pound which can be saved in the other parts, and in the car the construction should be such as to make every pound of weight of the structure count toward carrying the load. There is much yet to be done in both of these fields, and the track, bridge and operating offices have their part to perform. We do not believe that the course toward heavier locomotives can be checked, and that the co-related factors should be treated with this fact in view. The desire to "go one better" than one's neighbors in the weight and power of locomotives is not profitable. This principle of heavy engines needs careful treatment, and if the problem is studied with the care it deserves the Illinois Central experiment will probably be found to mark an epoch in locomotive practice. It should be kept in mind that track and structures improve slowly. The advance of the locomotive must not be too rapid for its suroundings.

Further analysis of the performance of these large engines on the Illinois Central is presented in another column in this issue; also a description of the remarkable engines just completed for the Atchison, Topeka & Santa Fe.

A DRAFTSMAN.

A young man, after working a few years in a drafting room, called at the editorial rooms of this journal to ask whether he was on the right track to success. He was told that he was and that some of the best railroad officers of the present time had spent a long time in this department. He went back to his table, determined to get out of the drafting room because of having shown his ability there. The next day brought the following letter, which we hope every draftsman will read:

"It seems to me to be a step in the right direction when one learns that there is no easy sailing, and makes up his mind to make an opportunity rather than wait for an opportunity to make him. I realize that it requires considerable determination and application to work ahead of oneself, preparing for something that may some time offer an opportunity or striving to gain knowledge that may be of value some time. The beginning is undoubtedly half the undertaking in any work, and difficulties apparently enormous at first, taken each in turn as they present themselves, should become simpler and finally be overcome."

We hold that there is no better place in which to gain experience than the drafting room. We also hold that a man who is a good draftsman and one who can organize and direct a drafting room properly has a combination of experience and qualities of the executive and the engineer which fit him for greater responsibilities. If this department is not appreciated, not only is a good opportunity lost by the management, but a number of promising, ambitious young men are discouraged and a great mistake is made. Drafting in railroad service is usually drudgery, but the men themselves may be to blame for this. They usually have it in their own hands to make its importance felt and to make the drafting room a good stage in progress from which they may graduate because of showing that they have a grasp on the important affairs with which they deal.

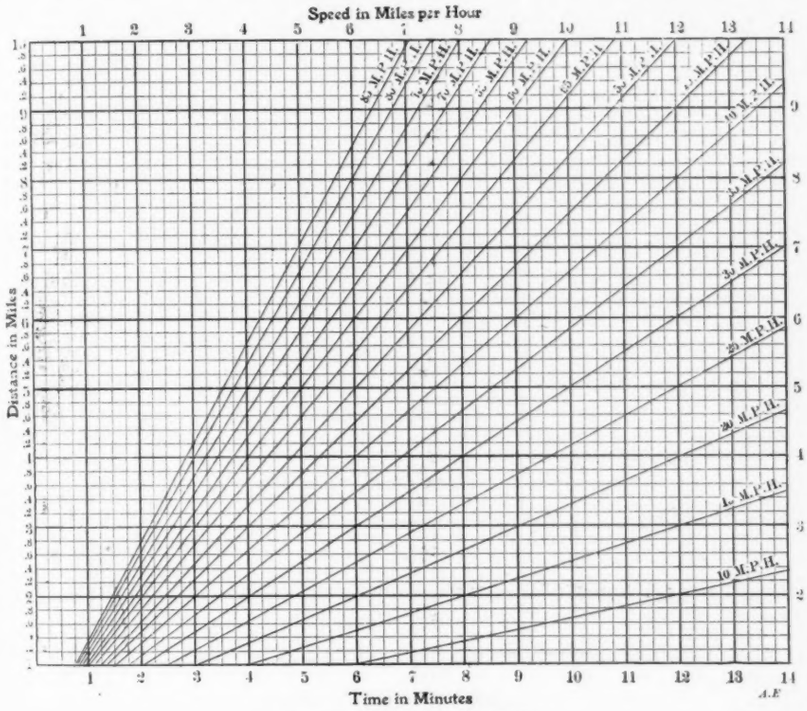
NEED OF INDUSTRIAL EDUCATION WITH REFERENCE TO THE MACHINE TRADE.

At the Baldwin Locomotive Works a new system of managing the apprentice problem has been inaugurated with a promising outlook. This plan was outlined on page 309 of our October number. In connection with apprentice training an educational system of some sort is necessary, and the views of Mr. Samuel M. Vauclain on this subject are recently expressed before the Engineers' Club of Philadelphia. In the course of his remarks Mr. Vauclain recommended that when our youth have left school and stand ready to enter upon their life's work, there should be a well-defined and improved system of indenture pursued by the owners of all industries to meet the various grades of boys seeking places. Those who have had less general education should be instructed in the shops for a longer term of service than those who have had a high school or collegiate training. He believed that the money now spent by the various trade schools should be devoted to a thorough teaching of mathematics and mechanical drawing, and perhaps chemistry and mechanics; while the shops of our nation could be organized into mechanical training schools already thoroughly equipped with teachers and machinery far more valuable than those now employed. He briefly described what is being done in this direction by the Baldwin Locomotive Works of Philadelphia, and pointed out that it would be better for every manufacturer to entrust his business to a competent stranger educated under his own roof than to an irresponsible and disinterested progeny.

A CONVENIENT TIME DIAGRAM.

The accompanying engraving, made from a diagram devised by Mr. W. R. Maurer, Chief Draftsman of the Motive Power Department of the Buffalo, Rochester & Pittsburgh Railway, will be found convenient in checking up time-tables and for various other purposes in connection with the time of trains. These limits of 14 minutes and 10 miles will cover nearly all ordinary time-tables. To ascertain the speed in miles per hour, find the intersection of the horizontal and vertical lines passing through the desired numbers.

If the speed of a train making 7.6 miles in 10¾ minutes is desired, it is found to be midway between the oblique lines at 40 and 45 miles per hour, or 42.5 miles per hour, which is near enough for practical purposes. When time-tables are made up, such a diagram would be a convenient check upon uniform speed, and its use would tend to prevent the frequent occurrence of schedules with perhaps 60 miles per hour up a hill and perhaps 40 miles per hour down on the other side. A diagram of this sort may be easily made with any desired number of spaces and oblique lines.



Convenient Time Diagram.

A second historical locomotive has just been deposited with Purdue University by the Baltimore & Ohio Railroad, as a result of interest shown by Mr. J. N. Barr and Mr. F. D. Underwood, when with that road, and Mr. F. D. Casanave, the present General Superintendent of Motive Power. The engine belongs to what is known as the "camel-back" type and is designated by the initials B. & O., No. 173. This type of locomotive was originated some forty years ago by Mr. Ross Winans, one of the most eminent of the early locomotive designers and builders. Engine No. 173 is of the ten-wheel type, and has cylinders 19 by 22 ins.; driving wheels, 50 ins. in diameter; weight on drivers, 56,500 lbs., and a total weight of 77,100 lbs. The shell of its boiler is 48 ins. in diameter. It was built in 1863, and has been in regular service until withdrawn to be put in order for delivery to the University, after which it made the trip from Baltimore to Lafayette under its own steam in six days. This engine of thirty odd years ago presents many interesting features, the whole machine being, in fact, designed with great skill and ingenuity. The name "camel-back," as may be surmised, was given to the engine on account of the peculiar appearance produced by the large cab on the central part of the barrel, and of the rapidly receding back end, with its staircase and handrail on the steeply inclined firebox, all of which gave the engine a humped appearance.

DOUBLE HEADING.

The Weakness Which It Exposes.

If the water, crane service, coaling stations or side-track facilities of a road are not up to date and are inefficient, the fact is most noticeable in connection with "double-headed" trains. The delays thus caused may even overbalance the gains which are expected from the reduction of train-crew wages. Double heading is a test of the efficiency of operation of a road. Mr. A. W. Sullivan, of the Illinois Central, recently expressed his views on this subject before the Central Railroad Club as follows:

The question of running double-headers I hardly think is one that can be considered settled. There are more points to it than the mechanical conditions of the service. The test of the question is, next to its economy, the efficiency of the service. For instance, if a double-headed train will get a given number of loads over the road quicker, as well as with less expense, then I think it can be said to be good practice; and if that can be done generally, it may be said to be good established practice; but it is very doubtful if that point has been reached. For example, I know of an instance where two large engines were double-headed because the superintendent thought he could make a better showing by double-heading two large engines than he could by double-heading two small engines; and in the course of the trip they came to a coaling station where each engine had to have 12 tons of coal; and while they had made very good time over the road, it took them about two hours to get away from that coaling station; and similarly at water stations that are not equipped with large-sized standpipes, it takes a long time to get water. Then, in side tracking trains at meeting and passing points; it is not generally the case to find the sidings long enough to take one of those long trains, along with another train in the opposite direction; and it is hardly safe nowadays, on lines of dense traffic, to count on only one train having to take the siding at a passing or meeting point.

While, of course, the economy of the saving of one train crew in moving double-headed trains must, of necessity, be admitted, there are offsets to that economy in the delays on the road, the consequent overtime, the damage that is done to cars in "sawing" trains at a meeting point where the sidings are not long enough to clear the main line, the difficulty of handling trains over hilly portions of the road, the uncertainty of trains moving on orders to make meeting points on short time, and a variety of other conditions which are essential elements of the transportation service, and tend to diminish the benefits that come from the consolidation of transportation units into large train loads, and of reducing the number of men required to move them over the road.

Mr. Sullivan's remarks also apply to heavy engines, and this may be accepted as an indication of the importance of putting roads into condition for handling larger trains. Double-heading and large locomotives demand better water, coaling and side-track facilities and stronger draft gear.

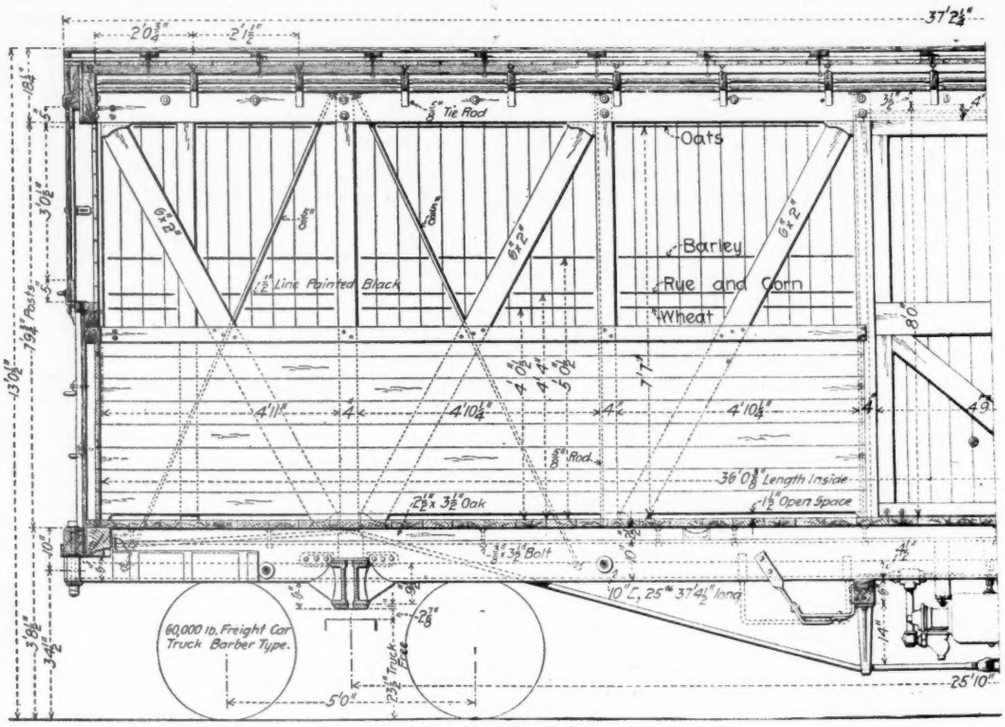
NEW CONSTRUCTION OF STEEL CENTER SILLS AND BOLSTERS.

Chicago, Milwaukee & St. Paul Railway.

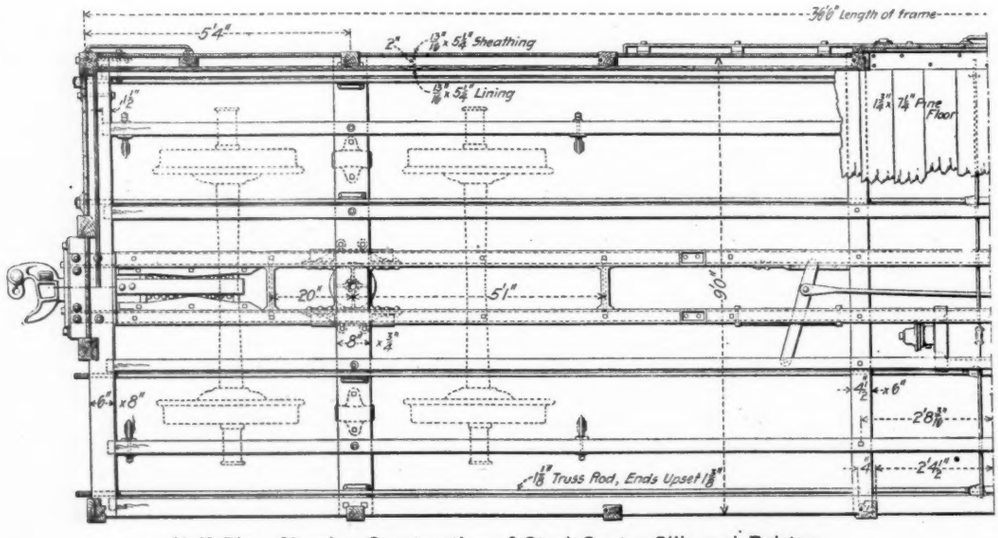
The Chicago, Milwaukee & St. Paul Railway has just turned out of its West Milwaukee shops a lot of new 60,000-lb. capacity wooden cars, the inside dimensions of which are in accordance with the recently adopted standard for 40-ton cars. These cars have continuous metal center sills and continuous metal body bolsters, the arrangement having been patented by Mr. J. J. Hennessey, Master Car Builder of the road.

The cuts herewith presented show that the arrangement employs two 10-in. 25-lb. channels for center sills, and the draft gear, in this case the Miner, is attached between the webs, which are placed 10⅞ ins. apart. The draft is central with the center sills and to meet this condition a novel arrangement of the body bolster was devised. The construction is easily understood by a glance at the sectional view at the bolster. A substantial spider casting is placed between the two members of the body bolster, and this casting has brackets or wings extending lengthwise of the car for 20 ins. under the center sills, and may be made longer if necessary. These brackets receive the entire load from the center sills, and when the spider casting and bolster are bolted together both members of the bolster are held firmly in place. The center plate is riveted to the lower member, while the upper member passes through the center sills at the neutral axis. These openings are reinforced by brackets riveted to the center sills. This prevents movement of the bolster along the center sills. The object of cutting the sills for the passage of the upper members of the bolster at the neutral axis was to avoid weakening them as beams.

This method gives continuous body bolsters and continuous center sills, a very desirable feature. It permits of dealing



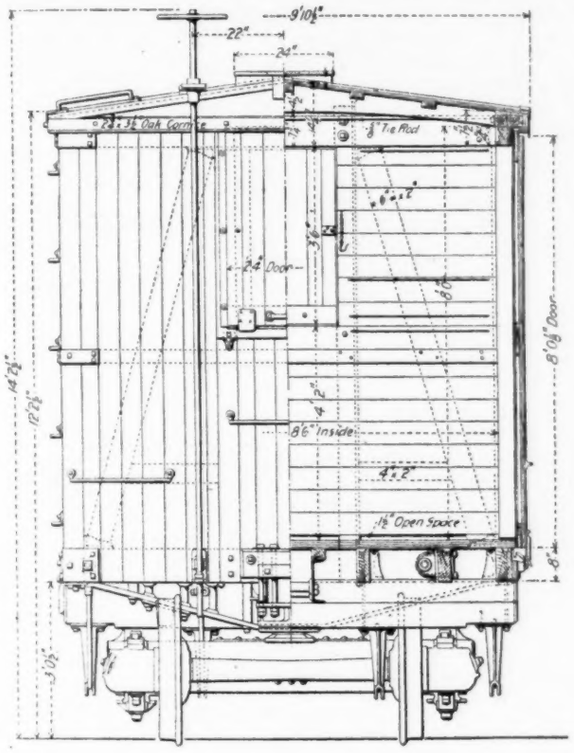
Half Side Elevation.



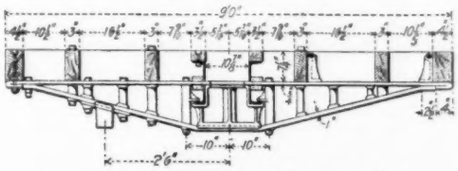
Half Plan, Showing Construction of Steel Center Sills and Bolsters.

New Construction of Steel Center Sills and Bolsters—Chicago, Milwaukee & St. Paul Railway.

with the pulling and buffing stresses in straight lines and provides for this feature without the sacrifice of strength which results from dividing the bolsters at the center sills or the center sills at the bolsters, or cutting any of the sills at the bolsters. In case of a wreck the metal center sills may be as easily removed and replaced as in the usual construction of wooden cars, which is an unusual feature in the use of steel sills. This bolster is 9½ ins. deep between the upper and



End Elevation and Section.



Transverse Section of Underframing.

lower members. If necessary to use a higher truck this distance may be reduced to 7 ins. These steel center sills are standard commercial shapes and may be readily replaced if damaged in wrecks. It is obvious that they supply the functions of continuous draft attachments and also furnish a substantial backbone to the underframe. Cars constructed in this way have been in service some eight months and careful inspection shows them to be in excellent condition. Mr. Hennessey has devised an interesting and valuable combination. These cars are equipped with Barber trucks, furnished by the Standard Car Truck Company.

The Lehigh Valley Railroad, in a recent circular, gave the number of articles of various descriptions found during the year in the coaches of passenger trains on a certain railroad as 1,270. This does not include articles found on Pullman cars. Of these articles 288 were claimed and returned to owners, the balance of the number, 982, still remaining in the hands of the baggage department of the company, awaiting claimants. It is hard to explain the low percentage of calls made for such articles left on trains, unless it be that passengers, in the main, do not understand that such articles that are found and turned into the baggage departments of the various railroads are held there subject to orders of the owners.

COMPARING HEAVY AND LIGHT LOCOMOTIVES.

By Edward Grafstrom,

Mechanical Engineer, Atchison, Topeka & Santa Fe Railway.

The descriptions of the road tests on the Illinois Central Ry. (American Engineer, November, 1901, page 343), and on the Michigan Central Ry. (American Engineer, December, 1901, page 379), are valuable contributions to current railroad literature, and deserve more than passing notice from the student of railroad economies, whether he be a mechanical or an operating official.

Both the tests were made for the purpose of enabling the managements of the respective roads to determine the comparative value of heavy and light locomotives, but while the one presents the results in shape for use of the general manager, the other one appears to have been carried out to serve, primarily, the Superintendent of Motive Power. In other words, while one was made for the purpose of determining the economy of heavy versus light locomotives, the other one was apparently intended to determine the relative efficiency of two types of locomotives, different in weight as well as in construction. Although thus not of the same scope, they both seem to have given the parties interested the information wanted to decide between the purchase of light or heavy additional power. Supplemented by intimate knowledge of local conditions and limitations the results of either test are undoubtedly sufficient, but as these results have been published and may be taken into consideration for similar purposes by officials of other roads than those on which the tests were made, it becomes interesting to analyze the published reports, in order to understand them correctly.

The Illinois Central test was made with four engines, each one a fair representative of its class, but all of the old school of design: simple expansion, narrow firebox, D-valves (with one exception). The trains were taken as they came, fast or slow, full rating or not. Cars were set off or picked up along the line. The delays were frequent and irregular; sometimes an engine was held for two hours while its train was being weighed, car for car. In fact, the traffic demands were such that the test may be said to represent average service conditions, with scarcely any attempt to favor the engines.

The Michigan Central test, on the contrary, was made with a good representative of the old type of narrow firebox, single expansion engine, in contrast with a modern compound with a wide firebox, high pressure, and piston valves. The trains were selected in accord with the rating of each engine, and the engines were favored in every way, thus giving results that do not obtain under ordinary service conditions.

It is not surprising that the fuel consumption on the Illinois Central test engines was so much higher than that of the Michigan Central. The Illinois Central ten-wheeler (No. 35) and the Michigan Central mogul (No. 126) have the same size cylinders, yet the Illinois Central ten-wheeler burned 1,059 pounds of coal to the Michigan Central mogul's 816 pounds per 10,000 ton miles. The difference in the quality of the coal used by each company during the test is undoubtedly responsible for some of this, but the service conditions during the tests, nevertheless, account for the most of it.

Aside from the calorific value of the coal used, its commercial worth in different localities affects the net results of a comparative test more than the fluctuations in wages or any other items. In the Illinois Central test the coal appears to have cost $1.03 per ton delivered on the tender. If the price of coal had been twice as high (which is not unusual on a number of railroads), the total operating expenses per 10,000 ton miles for the locomotives in that test would have shown up as follows, other items remaining undisturbed:

	Cost at $1.03	Cost at $2.06
10-wheel	$1.93	$2.48
Mogul	2.02	2.60
Consolidation	1.86	2.48
12-wheel	1.87	2.50

From which it will be seen that in some localities the operating cost of the ten-wheel engine would be as economical as that of the heavy consolidation, and, furthermore, if the price of coal be still higher, the ten-wheel would actually become the more economical of the two.

There is still another important side of the question to consider, and that is the investor's or stockholder's. If we have, say, half a million dollars to invest in new locomotives, what size will give the best return for the money? Interest, taxes, and depreciations being the same for the total amount, whether light or heavy locomotives are bought, and taking the traffic conditions and topography of the Illinois Central for a basis, the proposition would appear as follows:

Suppose that $500,000 will procure 44 ten-wheelers of the No. 35 class at $11,363.63, or 31 twelve-wheelers of the No. 640 class at $16,129,03. Using the Illinois Central test data as a measure and assuming that all the engines of either class would make as many trips in the same length of time, we find that when each engine has made 10,000 miles, the 44 ten-wheelers would aggregate 473,598,972 ton-miles, while the 31 twelve-wheelers would foot up to 468,492,047 ton-miles. The total cost of hauling the tonnage with the ten-wheelers would be $91,-400.82, at $1.93 per 10,000 ton-miles. With the twelve-wheelers the corresponding cost would be $87,627.44 at $1.87 per 10,000 ton-miles. Consequently more revenue would be had at a higher operating cost if the half million is invested in ten-wheelers, than if the twelve-wheelers had been chosen.

Again, if it was possible to buy only 42 ten-wheelers at a cost of $11,904.76, instead of 44 at $11,363.63, the result would have been a gross tonnage-mileage of 452,071,746, at a cost of $87,247.58 at $1.93 per 10,000 ton-miles. Thus with only 42 ten-wheelers both revenue and cost of hauling would be lower than with the twelve-wheelers. For easy comparison of these figures, the following table is given:

Number of Engines.	Type	Ton Miles.	Cost per 10,000 Ton-miles.
44	10-wheel	473,598,972	$91,400.82
31	12-wheel	468,492,047	87,627.44
42	10-wheel	452,071,746	87,247.58

It will thus be seen that the number of engines which a certain sum will buy, or, in other words, the cost of each engine, will play an important part in determining the size most suitable for certain conditions. Taking everything into consideration, the large engine is therefore not always economical in proportion to its size.

In stationary practice it is customary to so select power units that each engine can either run at its full capacity or not at all, and if this practice should be carried into railroad financiering it would be found that those engines which most frequently haul their full rating would prove the cheapest ones in the long run. This is another argument in favor of moderating the size of engines to suit the traffic demands, instead of blindly following the lead of other roads on which the heaviest engines built are none too large and always have their full trains waiting for them.

METAL CARLINES—PERE MARQUETTE RAILROAD.

The thickness of car roofs has not been specially important until the adoption of the standard inside dimensions of box cars by the American Railway Association made it difficult for some roads to keep within the demands, because of the height of the standard car at the eaves. Mr. B. Haskell, Superintendent Motive Power of the Pere Marquette, has devised a pressed steel carline which makes it possible to gain two inches at these points. These carlines are pressed out of 3/16-in. steel and 7 of them take the place of 11 or 12 wooden carlines in a 38-ft. car. Mr. Haskell describes a test in which 7½ tons of pig iron were evenly distributed over the running board of a car using this construction and allowed to remain for four hours, with a deflection of ⅜ in. After removing this load there was no permanent set. This method of construction shortens the posts, braces and siding, thereby saving in the cost of lumber and reducing the weight of a car about 200 lbs.

CORRESPONDENCE.

INCREASING SIZE OF LOCOMOTIVE DETAILS.

To the Editor:

Since reading the comments on the four-cylinder compound locomotive on page 319 of your issue of October last, I have done a lot of thinking about our modern locomotives of enormous weight and size. In passing through the shop yesterday I came across two high-priced machinists moving, by aid of a bar and roller, the main rods of one of our heavy consolidation engines, and was struck at once as never before with the great weight of these parts. You will criticize me for allowing high-priced men to do the work of laborers, but that is aside from the point I am making, which is that of the increasing size of locomotive details. They have grown during the past five years to an extent which I admit I did not, and I do not believe the majority of your readers, appreciate.

For the sake of comparison I send you two prints showing

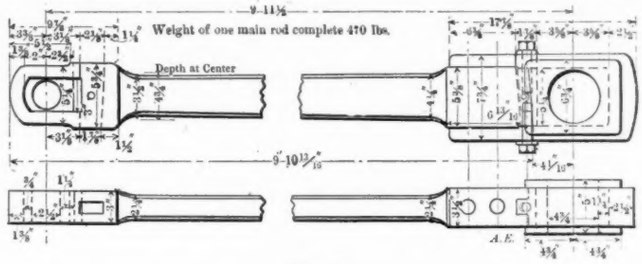


Fig. 1.

main rods. One is from a very heavy, recently built consolidation locomotive, and the other from a ten-wheel engine built in 1890. The former main rod weights 1,050 lbs., complete, and the latter 470 lbs. These rods are from the heaviest engines on our road at the times they were built, and they fairly represent the increased weight of these parts in our vicinity.

We are not having less, but more, trouble with engine failures than formerly, which goes to show that the progress of ten years which has brought out such heavy engines has not resulted in the relief which improved design should bring. There is no doubt but that engines are now loaded more nearly to their ultimate capacity than ever before. But this applies to the engines built ten years ago as well as to new ones, and it

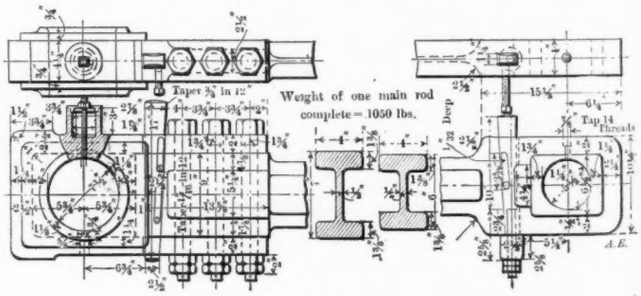


Fig. 2.

is a fact that the big engines of to-day break down oftener than those which have been in service for ten years.

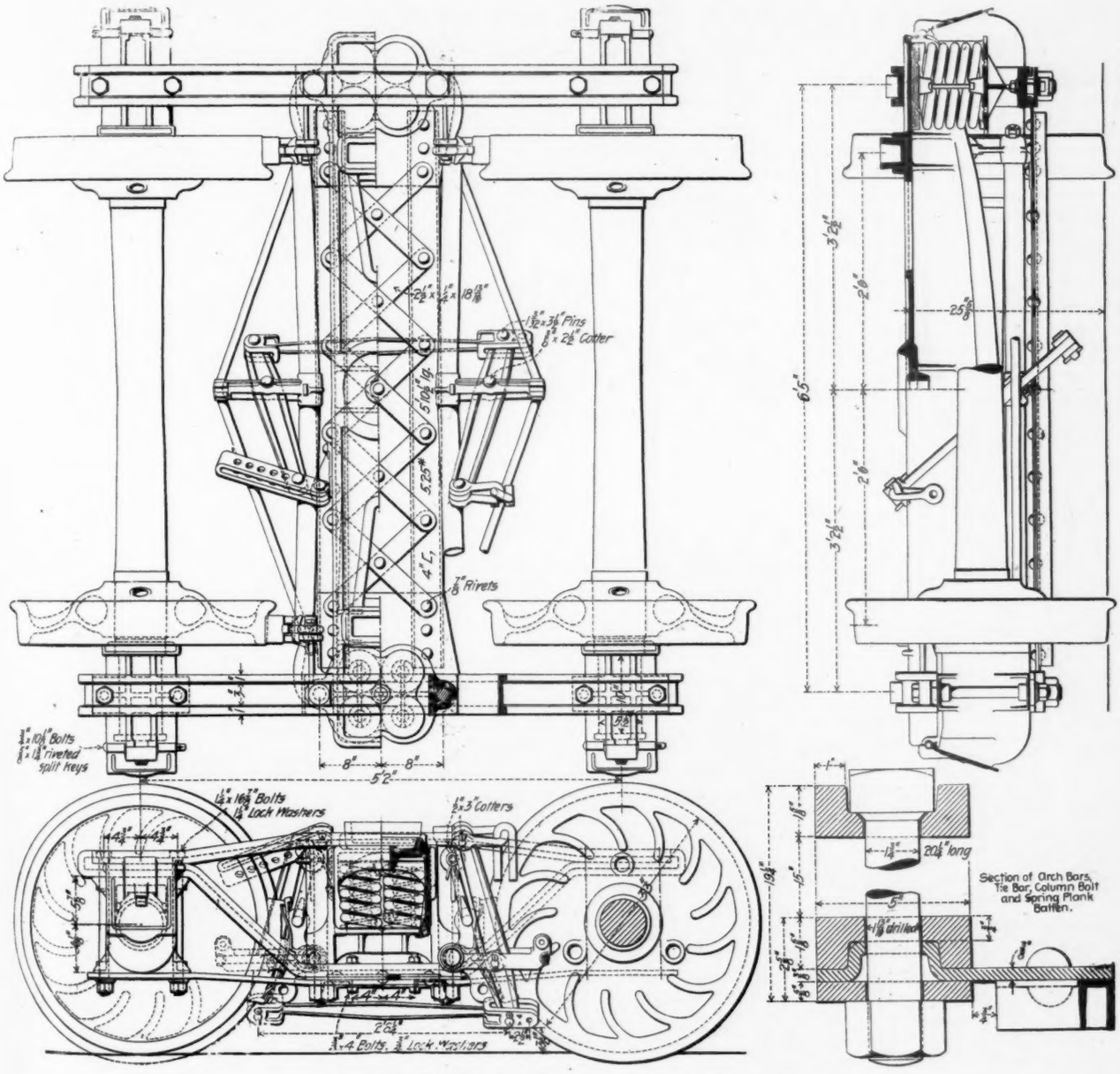
I believe that this means that the increase of running repairs will drive us into lighter loading of engines, or into designs which will make it possible to divide the work up among a greater number of parts. I have no doubt that the four-cylinder balanced compound with four main rods instead of two will help us out in this respect. The crank axle and the increased number of parts of this engine over the ordinary types of course means greater complication, but we must do something like this or else decrease the weight of trains. Ten years ago I had no difficulty to keep the number of "laid up for repairs" engines down to 7 per cent. I have hard work to keep the proportion below 10 per cent., as we are operating to-day. In this matter boiler work figures heavily, but the comparison of the rods represents the situation pretty clearly.

SUPERINTENDENT OF MACHINERY.

[Editor's Note.—These two main rods tell an important story. We present both of them in the accompanying engravings.]

A STEEL CHANNEL ARCH-BAR TRUCK FOR 50-TON CARS.

The accompanying engravings illustrate a steel truck designed by Mr. George I. King and adopted as a standard in the construction of steel cars of 50 tons capacity. Special attention is directed to the latticed spring plank with its embossed end battens fitting snugly into the lower arch-bar channels. This fit extends for a length of 20 ins. along the bottom arch bar and is relied upon to keep both side frames of the truck in parallel alignment under all conditions of service, relieving the bolts of this duty. The channel-shaped arch bars offer the advantage of a maximum of strength with a minimum of dead weight, and they may now be obtained from two of the prominent steel companies. It should be noted that the brakes are hung from the cast-steel end castings of the truck and are thus rigidly hung from the truck frame and not from the bolsters. With this construction the brake shoes remain always at the same distance above the rail, which is not true of trucks in which they are hung from the bolsters. This arrangement gives a large amount of room available for brake beams, and avoids the difficulties which have been experienced with some of the patented beams for which there is insufficient space when the brake hangers are hung in the usual way. In this truck the side bearings have been located 60 ins. from center to center, and adjustable cast-iron fillers are placed in the side bearing pockets, with a view of adjusting the desired clearance between the body and truck side bearings by means of shims. This truck employs 5½ by 10-in. axles, malleable iron journal boxes, pressed steel lids, special channel arch bars, cast-steel bolsters and end castings, malleable-iron brake levers and National Hollow Brake Beams.



A Steel Channel Arch-Bar Truck for 50-Ton Cars.

In a recent extended trip by a representative of this journal among the motive power departments of the East and Middle West the chief topic of conversation was the introduction of piece work. It was not confined to car departments, but also included locomotive work. It was not spoken of altogether as a good move on the part of the road, for business reasons alone, but there seemed to be a general feeling favoring better relations with the men for mutual benefit.

TESTS NEEDED ON THE LENGTH OF BOILER TUBES.

The difficulties in the way of establishing definite ratios between the factors of locomotive construction are generally understood and are so thoroughly appreciated that comparatively little has ever been done in an experimental way to guide the designer. It is the difficulty rather than the lack of appreciation of the need that has led to the use of the "cut and try" method so generally in this practice, but there seems to be good reason to believe that a good deal might be accomplished by concerted and concentrated effort if it can be started. We would like to give emphasis to the following paragraph from one of the recent Master Mechanics' Association reports which appeared in connection with the subject of the most favorable lengths of boiler tubes:

"One of the unfortunate conditions under which this association works is that of being unable to make appropriations for carrying on scientific investigations of subjects of vital interest to all railroads. It is to be hoped that in time the powers controlling the railroad purse strings will undergo a change of heart and find that it will be to their interest to furnish a pro rata amount, sufficient to enable the Association to hire experts to conduct researches along important mechanical lines. Action of this kind would prove economical to the individual railroad, by relieving it of the expense incurred in making individual research, and by furnishing to all railroads a central source of authority to which they can turn for information, thereby making the American Railway Master Mechanics' Association a far stronger society in the eyes of the world. Let us hope that these conditions may come to pass. In the meantime some of our more ambitious members are investigating for themselves, or in many cases cutting and trying in order to obtain definite information along some of these lines, and each effort meeting with good results will be an encouragement to go a little further."

The particular subject referred to, boiler tubes, merits and really needs investigation. Radical differences of opinion are held by locomotive men as to the wisdom of the present tendency toward increasing the ratios of lengths to diameter and a thorough experimental investigation would give an answer which would be not only much quicker but more reliable than that derived from the slow process of "survival of the fittest." Furthermore, the concentration of expense of many practical experiments in actual construction into a series of carefully conducted tests would be economical in the end. It may also be said that when a new engine is built with long tubes there are likely to be other factors of the construction which tend to obscure the results from the special feature upon which information is most desired. The laboratory method renders it possible to confine the attention to the chief point at issue and eliminates the influence of other, perhaps disturbing factors. It seems very desirable to establish certain relationships between lengths and diameters of boiler tubes which would serve as a guide to future practice under present conditions. This is a difficult and expensive undertaking, but it cannot be done better than under the direction and control of the Master Mechanics' Association.

Up to the present time there are no records on this subject which apply to modern American locomotive practice, as it is generally admitted that Mr. Henry's experiments on the Paris, Lyons & Mediterranean Railway, recorded in the "Railroad and Engineering Journal" of August, 1890, were carried out on the lines of stationary rather than locomotive conditions and are, therefore, not to be relied upon now. In spite of this fact, these tests are continually quoted in support of short tubes, and they have, undoubtedly, had a strong influence on the construction of locomotive boilers, the world over, for the past ten years. Something new is needed as a safe guide in the future and it is to be hoped that the rather mild suggestion in the report referred to may eventually bear fruit.

EXHAUST AND DRAUGHT IN LOCOMOTIVES.

The International Railway Congress in 1899 considered this subject from elaborate reports by Mr. C. H. Quereau, Mr. B. O. Ekman and Mr. Ed. Sauvage. After detailed discussion the Congress adopted conclusions intended to cover practice all over the world, which were printed in the November number of the "Bulletin," of 1901, as follows:

1. No general rule to decide on the choice between a fixed and variable blast can be laid down. This choice should take into account whether the locomotive does uniform or irregular work, the profile of the lines run over, the loads drawn, the length of run between stops, the kind of fuel used, the cost of maintenance of the apparatus, and the care and skill of the staff.

2. The simple circular fixed blast and the variable blast fitted with two flap valves appear to satisfy most of the requirements met with in practice.

3. More complicated arrangements, such as the blast fitted with petticoat above it, the deflector plate fixed in the smokebox, the annular blast, either fixed or variable, the variable blast with sliding sleeve, by-pass for a portion of the steam, etc., may give good results, but do not as a rule appear to show any great superiority over the two simple forms mentioned above, provided that the latter are suitably arranged. Blast pipes are subject to rapid incrustation with dirt, which makes the maintenance of complex mechanism difficult; this incrustation is frequently unequal in the case of annular blasts.

4. The dimensions of the blast pipe and of the chimney and also the position of the blast pipe, may be determined by certain formulæ, but it is advisable to verify the results by actual experiments on each class of locomotive; practical tests alone form the real criterion.

5. When the blast opens into the upper portion of the smokebox, as is generally the case throughout Europe, it appears advisable not to raise the opening much above the upper row of tubes. When the blast opening is in the lower portion of the smokebox, it should be fitted with a petticoat. It does not appear that this arrangement, which, moreover, possesses some disadvantages, shows any great superiority over others. It is of great importance to provide a large and easy entry for the gases into the lower end of the chimney. There is a general tendency to somewhat increase the opening by making the upper portion of the chimney conical.

6. The length of smokebox may attain and even exceed 2 meters (6 ft. 6¾ ins.) without producing an unfavorable effect on the draught. Large smokeboxes may serve as a receptacle for cinders; the chimney should then be placed sufficiently far back; but it is advisable, when no deflector plate is used, to place the chimney sufficiently far from the tube plate to ensure equal distribution of the gases throughout the tubes. When it is not desired to catch the cinders in the smokebox, the length may be reduced to about 1.50 meter (4 ft. 11 ins.) in accordance with recent American practice.

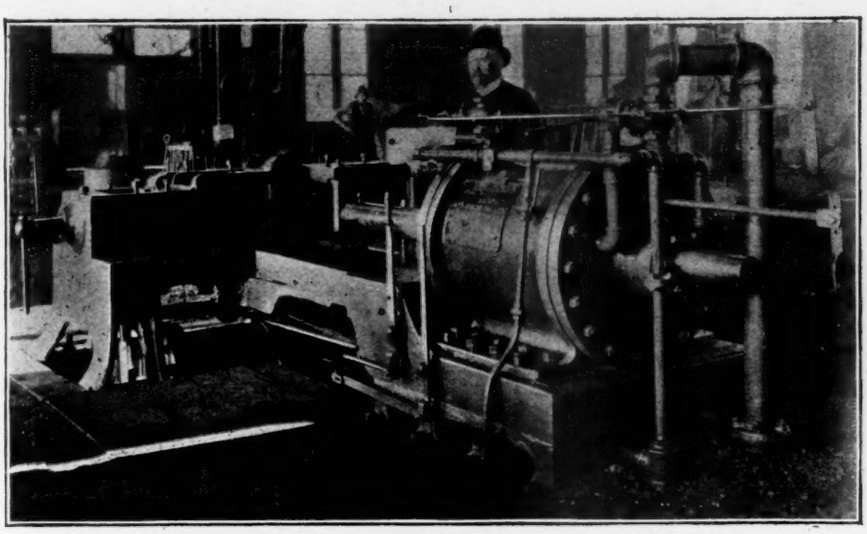
7. Spark arresting devices are rarely very efficient without impeding the draught. It is, therefore, advisable to use these appliances as little as possible, and to simplify them to as great an extent as the quality of the fuel and the character of the country run through may permit.

Of all apparatus intended to utilize the waste heat of the exhaust steam, the exhaust steam injector is the only one which is found frequently in use; this apparatus appears to ensure some small economy in fuel, and to result in easier steaming.

The Beaumont oil field now has 110 active wells, 27 new "gushers" having been added during the month of November. At that time the total tank capacity at that point amounted to 1,280,000 barrels.

PNEUMATIC FORGING MACHINES AND WHAT THEY WILL DO.

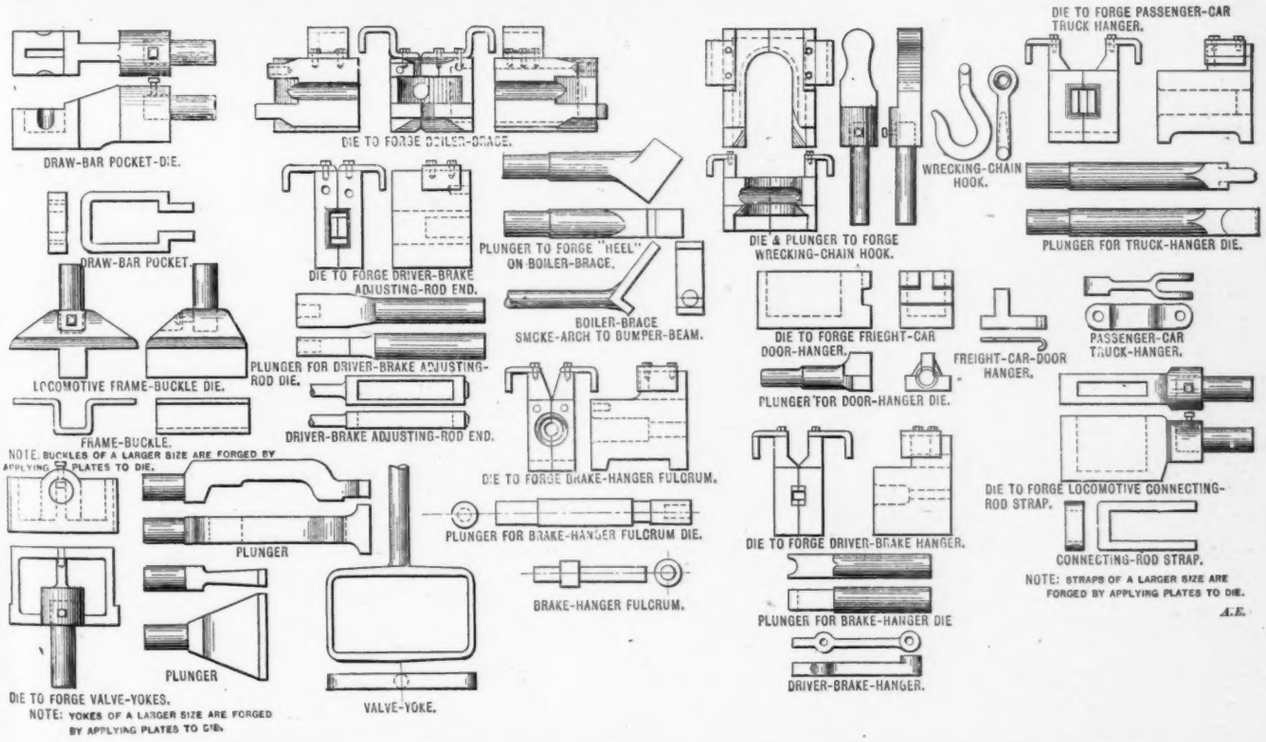
At the Burnside shops of the Illinois Central Railroad are being built six very powerful pneumatic forging machines of three different sizes, two of which weigh 15 tons each and have cylinders 24 by 31 ins., two 9 tons each with cylinders 20 by 26 ins., and two of 5 tons with cylinders 16 by 22 ins. They are for use in the Burnside shops, and are similar to the two pneumatic forging machines already in use at that place.



24 by 31 in. Pneumatic Forging Machine.

The accompanying engraving of one of the largest of these tools shows a 24-in. air cylinder bolted to the top of the longer arm of the bed-plate and used to operate the plunger or male die. On each end of the two short arms of the frame is an adjustable die-block which has dovetailed and grooved connections with the bed-plate, and moves at right angles to that of the plunger. For such work as welding and the more complicated operations in forging there is a 24-in. auxiliary air cylinder under the machine, which operates one of these die-blocks as a pneumatic hammer for delivering lateral blows. The plunger piston and die-block piston can be operated either separately or in conjunction with each other. The air pressure used is 125 lbs. By opening and closing the lever valve over the main air cylinder a static pressure or a blow of 60,000 lbs. is delivered to the work, and in either case the force is controlled by opening and closing a cut-out cock in the line of piping. The working of one of these machines was fully described on page 289 of the September, 1900, issue of this journal.

The capacity of this tool is limited by the amount of iron that can be heated and brought to the dies. Four men, and a boy to operate the machine, can turn out 600 arch-bars a day of ten hours. To forge a valve yoke at a fire requires three men; a blacksmith, who receives $2.90 per day, and two helpers, each receiving $1.70 per day. In ten hours these men will turn out three valve-yokes, while with two men and a boy at the machine 30 valve yokes are finished in the same length of time. The man in charge of the machine gets $2 a day, his helper $1.60, and the boy who operates the machine, $1.10 a day. This gives, as the cost of labor for one valve-yoke, about 15¾ cents when finished in the machine, and $2.10 when finished by hand. To forge a strap for the side rod of a locomotive, which weighs 236 lbs., requires a blacksmith and three helpers working two hours. The blacksmith at $2.30, and the helpers at $1.70 each. By the use of the machine two men and a boy will forge a strap in 47 seconds. A few of the dies used and the work they perform are shown by drawings in the second


DRAW-BAR POCKET-DIE.
DRAW-BAR POCKET.
LOCOMOTIVE FRAME-BUCKLE DIE.
FRAME-BUCKLE.
NOTE. BUCKLES OF A LARGER SIZE ARE FORGED BY APPLYING PLATES TO DIE.
PLUNGER
PLUNGER
DIE TO FORGE VALVE-YOKES.
NOTE: YOKES OF A LARGER SIZE ARE FORGED BY APPLYING PLATES TO DIE.
VALVE-YOKE.
DIE TO FORGE BOILER-BRACE.
DIE TO FORGE DRIVER-BRAKE ADJUSTING-ROD END.
PLUNGER FOR DRIVER-BRAKE ADJUSTING-ROD DIE.
DRIVER-BRAKE ADJUSTING-ROD END.
PLUNGER TO FORGE "HEEL" ON BOILER-BRACE.
BOILER-BRACE SMOKE-ARCH TO BUMPER-BEAM.
DIE TO FORGE BRAKE-HANGER FULCRUM.
PLUNGER FOR BRAKE-HANGER FULCRUM DIE.
BRAKE-HANGER FULCRUM.
DIE & PLUNGER TO FORGE WRECKING-CHAIN HOOK.
WRECKING-CHAIN HOOK.
DIE TO FORGE PASSENGER-CAR TRUCK HANGER.
PLUNGER FOR TRUCK-HANGER DIE.
DIE TO FORGE FRIEGHT-CAR DOOR-HANGER.
PLUNGER FOR DOOR-HANGER DIE.
FREIGHT-CAR-DOOR HANGER.
PASSENGER-CAR TRUCK-HANGER.
DIE TO FORGE DRIVER-BRAKE HANGER.
PLUNGER FOR BRAKE-HANGER DIE
DRIVER-BRAKE-HANGER.
DIE TO FORGE LOCOMOTIVE CONNECTING-ROD STRAP.
CONNECTING-ROD STRAP.
NOTE: STRAPS OF A LARGER SIZE ARE FORGED BY APPLYING PLATES TO DIE.
A.E.

Some Dies Used and the Work Performed by Pneumatic Forging Machine—Illinois Central Railroad.

engraving on page 59. All these forgings are made by two men and a boy. The construction of this machine permits of using very much smaller dies than any other machine doing the same class of work, and it takes fewer of them. For quite a large number of forgings the dies are always set, so that it only requires a plunger to do the work. In a number of cases the same plunger is used for different forgings. To make different sizes of the same forging for example, say, a strap for a locomotive side rod 5 or 6 ins. wide is wanted, and the plunger to be used has been made for a strap 4 or 4½ ins. wide. In this case the machine forges a liner around the plunger, and with different thicknesses of liners as many different sizes of straps can be forged. In making various sizes of valve-yokes the plunger is made for the smallest size and liners used in forging larger sizes. This machine requires no belting, gearing or lubrication. It will give repeated short, quick blows, when desired, without returning to the end of the stroke.

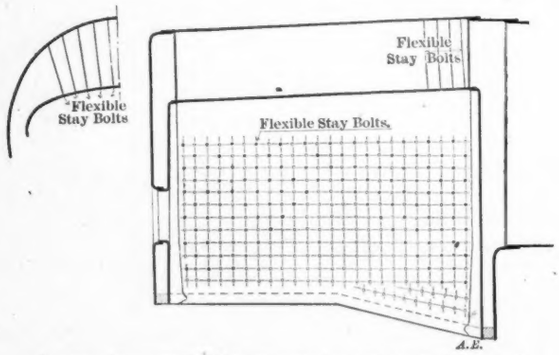
The great variety of work performed, ranges from the heaviest of forgings to the smallest S hook, and must be seen to appreciated.

Through the ease of changing dies, which for the majority of complicated operations simply lift in and out of the die-blocks, nearly all are accomplished in one heat, the time required to change dies in all cases ranging from 1 to 3 minutes. An inspection of this machine and its work indicates it to be a valuable labor saver. Not only does its work cover a wide range in each individual machine, but the machine itself may be built in a variety of forms for adaptation to the work of different departments of rolling stock construction. We are indebted to Mr. M. Kennedy, foreman of the Burnside blacksmith shop, for this information.

APPLICATION OF FLEXIBLE STAY BOLTS TO LOCOMOTIVE BOILERS.

Wabash Railroad.

While a great deal of attention has been given to the construction of stay bolts, with a view of providing for bending without danger of breaking, little has been recorded with reference to the location of these special stay bolts in boilers. In our December number, 1900, the ball and socket stay bolt designed by Mr. J. B. Barnes, of the Wabash Railroad, was described and illustrated. This is now called the "Acme Flexible Stay Bolt," and from the manufacturer, Mr. C. A. Thompson, of St. Louis, we have received a drawing showing its application to a recent lot of new locomotives built for that road by the Richmond Locomotive Works.



Application of Flexible Staybolts—Wabash Railroad.

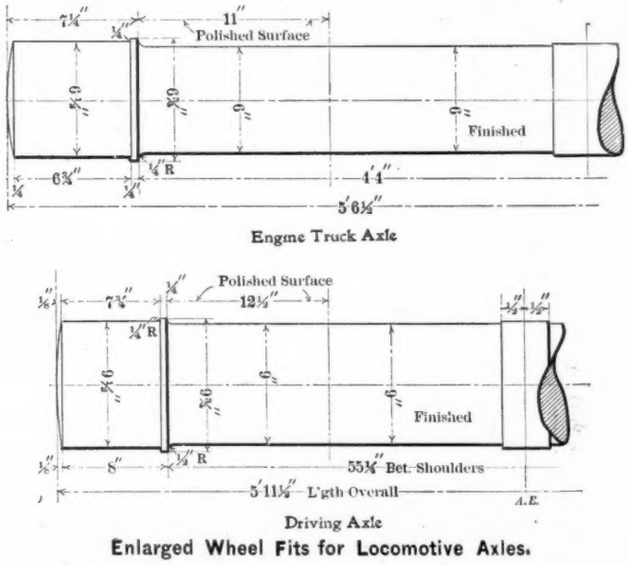
While there is no fixed rule for their location in the fireboxes, the practice of this road may be followed safely. About 100 of these flexible stays are distributed over each side sheet, as indicated in the sketch, their locations being governed by experience with the breakage of bolts of the usual form. In this case they are used in alternate spaces except in a central portion of A shape. In the back head about 36 are applied and in the front end of the crown sheet about 40, making nearly 280 in all. There are none in the throat sheet. At the front end of the crown sheet four transverse rows are put in, and these extend five rows each side of the center.

Mr. Barnes states that thus far he has not found a single broken stay bolt of this kind, and from the examination of side sheets when engines have come in for wheel and driving box work the sheets appear to be in much better condition than those having the old form of bolts exclusively. Mr. Thompson believes that the cracking of side sheets will be overcome by the use of these flexible stays. Those which have been in service for a year or more and have been removed for examination show the under side of the head to be worn bright and smooth as if they had been freshly turned and ground, but no scale has been found under the heads. This appears to demonstrate conclusively the flexibility of these bolts.

AXLES WITH ENLARGED WHEEL FITS.

Delaware & Hudson Company.

These drawings are presented as a reminder of good practice, for the application of enlarged wheel fits is not new. It is not as general, however, as the merits of the idea seem to warrant. When axles are made large in diameter where they are inaccessible for inspection the chances for unsuspected cracks are greatly reduced, and it is surprising that all driving and engine truck axles are not made in this way. The same remark applies also to crank pins. During the past three years attention has been repeatedly directed in our columns to this principle, and another example is now added to the list. At the inside of the wheel fit a collar is left on the axle to aid in meeting the severe thrusts due to the shocks from suddenly entering curves. At the center of each axle a space is left rough in order to receive the record of the material, date of manufacture and application, which is stamped upon it. A driving and a truck axle are shown in the drawing. This is the standard practice of the Delaware & Hudson Company, and in time it will undoubtedly be in general use.



Enlarged Wheel Fits for Locomotive Axles.

The Crane Company, of Chicago, in connection with its profit-sharing plan, inaugurated three years ago, distributed nearly $125,000 to its employees January 1. Five per cent. of the amount paid each employee in wages during the year 1901 was thus awarded without reference to the length of service.

A PARADOX IN CONNECTING ROD DESIGN.

By Geo. L. Summers, M. E.

The accompanying diagrams show in an interesting manner a peculiarity in the design of connecting rods; that is, by adding more metal to certain parts of the rod section the rod not only is not strengthened, but may even be made weaker.

A section of a main rod, of good design, with flanges ⅞ in. thick, is shown in Fig. 1. If the flanges be gradually thickened the rod will attain a maximum strength when the flanges are 19/16 ins. thick, and the strength will then decrease until the flanges come together in the center.

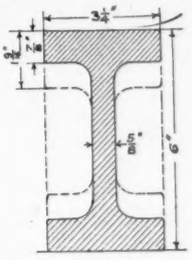


FIG. 1.

The curves reproduced in Fig. 2 show graphically:

That inside of certain limits the fiber stress as a long column may, for commercial purposes, be taken as the pressure divided by the area.

That if a strong enough rod cannot be obtained by adding a small amount to the inside of the flanges it is better to take a new section than to try to gain strength by making the flanges extremely thick.

The most economical point is reached where the depth of the flange equals about one-sixth of the total depth.

[Editor's Note.—This concise study of the design of locomotive connecting rods represents a portion of a commercial method of checking calculations, worked out by Mr. Summers. He has promised a thorough discussion of the design of connecting rods for a future issue.]

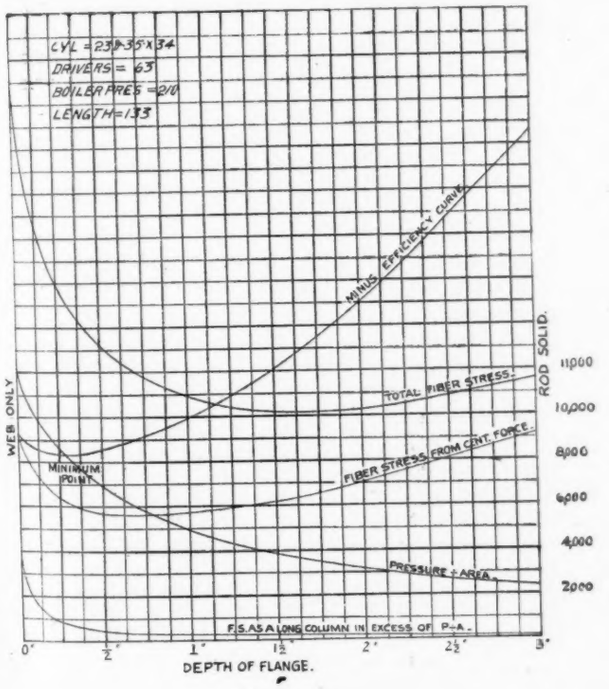


FIG. 2.

Mr. G. W. Kenney has been appointed superintendent motive power and rolling stock of the Rutland Railroad. Mr. J. J. Reed, formerly general foreman of the locomotive department of the D., L. & W. Railway at Scranton, Pa., has been appointed assistant superintendent motive power, and Mr. C. J. McMaster assistant superintendent rolling stock. The headquarters of all of these officers will be at Rutland, Vt.

PERSONALS.

Mr. R. P. Blake has been appointed mechanical engineer of the Northern Pacific, with headquarters at St. Paul, Minn.

Mr. M. R. Coutant, formerly mechanical engineer of the Wabash, has been appointed master mechanic of that road at Fort Wayne, Ind., to succeed Mr. G. S. McKee.

Mr. M. B. Hunt has been appointed mechanical engineer of the Erie, with headquarters at Susquehanna, to succeed Mr. T. H. Curtis.

Mr. J. J. Maguire has been appointed assistant purchasing agent of the Mexican Central Railway, to fill the position just now created. He will be located at No. 52 Broadway, New York.

Mr. John A. Orr has been appointed insurance inspector of the New York, New Haven & Hartford. He will inspect the insurance risks of the company, investigate fires affecting railroad property and act as adjuster for the railroad company.

Mr. George H. Goodell, who recently resigned as mechanical engineer of the Northern Pacific to enter the engineering department of the Pressed Steel Car Company, has been appointed chief engineer of the latter company. Mr. Goodell was for a number of years mechanical engineer of the Erie Railway.

Mr. W. A. Nettleton has been appointed assistant superintendent of machinery of the Atchison, Topeka & Santa Fe, with headquarters at Topeka, Kan. He was formerly superintendent of motive power of the Kansas City, Fort Scott & Memphis.

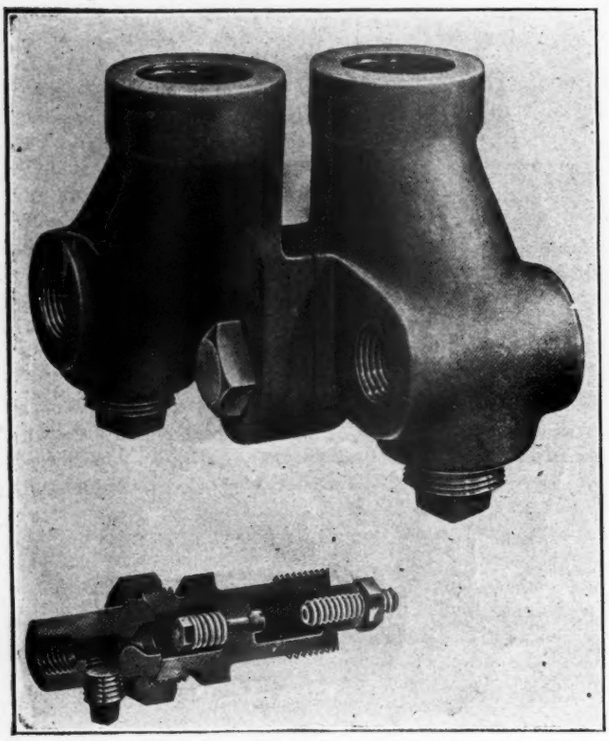
Mr. A. L. Humphrey, superintendent of motive power and car department of the Colorado & Southern, has been appointed superintendent of motive power of the Chicago & Alton, with headquarters at Bloomington, Ill., to succeed Mr. C. M. Mendenhall, resigned. Mr. Humphrey has been with the Colorado & Southern since July 1, 1900, and was formerly for nearly eight years in a similar position with the Colorado Midland.

ANGUS BROWN.

Angus Brown, Division Superintendent Motive Power of the New York Central at West Albany, was instantly killed by a train January 22, as he was going from his office to his home at noon. This shocking accident removes one of the most promising of the staff of the New York Central. He had been at West Albany less than a year, and in that time had won a position with superiors and subordinates which is given to but few men to attain, and the grief of all who knew him, especially those in immediate contact with him at Albany, is expressive of the highest honor and esteem and marked the influence of his quiet, unassuming, self-forgetful life. The writer was privileged to know him, and the sad duty of giving the news to his friends carries with it a melancholy pleasure in pointing to his high character, honesty of purpose, quiet and forceful way, which made him a power among men and brought him absolute trust and high regard from his officers. To these attributes were added an unusual ability and breadth of view. Such men are needed everywhere, and especially in charge of large bodies of men, where example is so important and where management is becoming increasingly difficult. He had a fine record of seventeen years on the Northern Pacific and was afterward Superintendent of Motive Power of the Wisconsin Central. As he was laid away one of the shop men said with tears, that he had never had such a superintendent.

IMPROVED "E" STYLE TRAP.

The accompanying engraving illustrates the improved "E" style trap of the American Locomotive Sander Company, which is a modification of the Leach D2 trap. This last mentioned trap has been found difficult to keep tight at feed-pipe unions, caused by the union nuts working loose, or pipes being of an irregular length. To correct these troubles the E trap is made in two parts, which are screwed separately on the ends of the feed pipes and then brought together and bolted. The bolt holes are oblong, which will allow for irregularities in pipe lengths. It may be applied in place of the D2 trap without any change in the pipe connections. The centers have been kept the same as with the old style. The triple trap is also furnished of a design to accomplish the same object as



Improved "E" Style Trap.

shown by the double trap. The extension air nozzle (1901 pattern), also shown in the engraving, is considerably heavier than the old style nozzle and has a ¼-in. pipe plug in the union sleeve instead of a small thumb screw formerly used. This new arrangement is handy for cleaning the air choke and has a threaded end. The union sleeve is also a ¼-in. pipe thread. It permits air piping to be introduced through it on all sides.

WATCHMAN'S IMPROVED TIME DETECTOR.

The Imhauser time detector in its improved form, as used in the United States Life Saving Service, and which was the only contrivance of its kind employed at the Pan-American Exposition, is a clock with chronometer adjustment and fully jeweled works. It is protected by a dust-proof cap and the outer edge is fitted with a safety knife blade lock attachment which cuts the dial every time the clock is opened or closed. There are 12 or 24 keys fitted, one to each station inside or outside the buildings. The watchman at arriving at a station inserts the key in the key-hole of his clock and turns it once to the right. This punches a figure on the dial at the exact time indicated by the clock. A single stamping spring made from the finest steel is used. It is attached to the cover and is completely independent of the watchman. The construction of the clock is such that tampering with it is out of the question. The highest award was given Imhauser & Co. for their exhibit at the Pan-American Exposition.

A BONUS SYSTEM.

Owing to the difficulty in our composing room, referred to in our January number, a number of articles were destroyed and could not be replaced in time for publication in that issue. Among these was the following reference to an important paper read before the American Society of Mechanical Engineers.

Unquestionably the most important subject brought before the society at this meeting was that introduced by Mr. H. L. Gantt in a paper entitled "A Bonus System of Rewarding Labor." In the paper and discussion chief prominence was given to the absolute necessity of establishing the base prices of systems of bonus, premium and piece work upon a correct basis. Mr. Gnatt carried this to a scientific point by the use of instruction cards for each piece of work. This gave the order of operations, the methods of placing the work in the machines, designated the tools to be used for each operation and the feeds and speeds for each. In fact, the cards reduced the process to a "rule of thumb," which was definite and complete. The effect was to reduce the cost of work to an astonishing extent and yet the men were happy. A bonus was earned by the men who carried out these instructions and completed the work in the specified time. The regular daily wage is paid if the bonus is not earned. This plan gives a bonus also to the foreman if the men make theirs, and the foreman's reward is greater if every man earns his bonus.

Premiums are paid, as was stated in the discussion, even to unskilled laborers for such work as shoveling and loading pig iron. Under the day work plan it cost nine cents per ton to load pig, and this was reduced to four cents, the wages going up from $1.25 to $1.85 for the work to accomplish this.

Two factors were considered absolutely essential to the success of any form of piece work: First, a correct basis of prices. Second, perfect and complete confidence on the part of the men that no change will be made in the rate until the introduction of new methods renders the old rate obsolete. While these have been pointed out again and again as the only possible foundation for success, the introduction of "piece work" continues with a strange disregard of these fundamentals.

Most organizations, such as railroads and manufacturing companies, grow from small beginnings, with a tendency toward the overlapping of functions and duties which involves unnecessary expense. One speaker described a study of his organization, employing 300 men, in which, by constructing a chart of the functions of officers and foremen, it was found that the lines crossed frequently. An hour's study of this chart showed where $3,600 could be saved annually by avoiding a few unnecessary duplications of work. The cost of these charts and that of the instruction cards, referred to, of course increased the general expense, but it was made clear that these functions, if performed at all, are usually done by men in the shop who are poorly qualified for them. It was better to intrust such things to specialists. This pointed clearly toward "rule of the thumb" methods in the work, but this was considered advantageous if intelligently carried out.

All of these suggestions came from large works, handling heavy pieces, such as heavy forgings, guns and crank shafts. The underlying principles, however, apply as well to smaller work and to all kinds of "piece work." This paper is suggestive even if too far advanced for most enterprises.

The locomotive industry of Austria comprises five different establishments, employing at present 5,200 workmen, viz.: The machine works at Florisdorf, with 1,300 men; the machine shops of the State Railway Company at Vienna, with 1,300 men; the locomotive works at Wienerneustadt, with 1,400 men; the Kraus Machine Factory at Vienna, with from 400 to 500 men; and the Bohemian-Moravian Locomotive Works at Prague, with 800 men. The total annual capacity of the five establishments is about 400 locomotives, and their annual earnings are between 20,000,000 and 25,000,000 crowns ($4,060,000 and $5,075,000).

BOOKS AND PAMPHLETS.

"Compressed Air: Its Production, Uses and Applications." By Gardner D. Hiscox, M. E. 820 pages, large octavo; 545 illustrations; cloth. Published by Norman W. Henley & Co., 132 Nassau street, New York, 1901. Price, $5.

This work assembles more tables, formulas and information concerning compressed air than have been gathered together before. It is a valuable treatise on the subject, and the large number of examples worked out to illustrate calculations constitute its most important feature. Many of the engravings record a state of the art in compressed air application which is constantly changing and will not long be up to date, but the treatment of principles will be valuable for a long time. The book treats of the thermodynamics of air, its compression, transmission, expansion, uses for power purposes, compressors, motors, air tools, sand blasts, air lift pumps, submarine work and refrigeration. It cannot be expected to give authoritative detailed information in so many items, but it is nevertheless the most complete work which has so far appeared on the subject.

"Metallurgy of Cast Iron." By Thomas D. West. Third Edition. Published by the Cleveland Printing & Publishing Company, Cleveland, Ohio, 1901. Price, $3.

The fact that this book is in its third edition speaks for its character. The author is well known for his systematic and persevering efforts to place foundry work above the plane of the time-honored methods, particularly as to the grading of iron by inspection. He stands for analysis of the pig, and has for years pursued the subject of the transverse testing of cast iron with a view of overcoming the wide variations in results which have in the past brought many men to believe that this form of test was not worth while, because its results were not reliable. In this direction Mr. West's efforts are crowned by the adoption of his ideas by the American Foundrymen's Association, and Chapter 70 contains a compilation of the tests of this association by which each grade of iron was found within twenty seconds by one ladle of iron, thus insuring the pouring of all bars of each grade at the same temperature. This result has never before been achieved in the pouring of test bars. Mr. West is thoroughly experienced as a foundryman, and gives the reader the benefit of his long experience and his opinions based thereon. He has studied blast furnace practice with a view of its application to the cupola, and he does not recommend anything which he has not tried and proved. He defines the effects of the various metalloids upon iron and treats in a thorough manner the principles of foundry work. A fair amount of attention is given to car wheels, and it is interesting to note his quotation of Mr. J. R. Whitney from the National Car and Locomotive Builder of May, 1889, on the expansion of iron in cooling. It is a valuable book for all who use or direct the use of cast iron.

"Dixon Automobile Graphites."—This little pamphlet presents the advantages of graphite for use on automobiles. The larger part of the pamphlet is devoted to testimonials from well-known men who have given the solid lubricant thorough tests.

The Electric Smelting & Aluminum Company, of Illinois, has begun equity proceedings to have Paul S. Reeves and S. K. Reeves, trading as Paul S. Reeves & Son, of Philadelphia, enjoined from making an alleged infringement of certain letters patent relating to improvements in manganese bronze, an alloy of commerce. This refers to the manufacture of manganese bronze, patents for which are controlled by the Ajax Metal Company, of Philadelphia.

Mr. W. H. Tew, formerly connected with the American Locomotive Company, Brooks Works, and later with the mechanical engineering department of the Chicago & Northwestern Railroad, has been appointed Managing Director of the newly organized German branch of the Standard Pneumatic Tool Company, with headquarters at Klosterstr, 13-15a, Berlin, Germany. This company is about to erect works at that place for the manufacture of "Little Giant" pneumatic tools and appliances for supplying the trade in Continental Europe.

The American Metal Hose Company, 40 Dearborn street, Chicago, have issued a catalogue of metal hose, their specialty being a double construction, the inside of which is copper and the outside of steel, made to stand rough use and high steam pressure. This hose has been adopted for use in the German navy and by the North German Lloyd Steamship Company. It is known as the Witzenmann system. The claims of this hose certainly warrant investigation by railroad officers with reference to its use for steam heating connections between cars and also for compressed air connections.

Exhaust Heads and Steam Traps.—The B. F. Sturtevant Company, of Boston, has issued a small catalogue, No. 119, illustrating and describing the Sturtevant exhaust head and steam trap. Tables of sizes and dimensions are included in the descriptions.

The Standard Pneumatic Tool Company has just issued a small pamphlet illustrating and describing their "Little Giant" pneumatic tools. The printing of the pamphlet is entirely in the German language, and it is for distribution among the trade in Germany.

The American Steam Gauge & Valve Manufacturing Company, Boston, Mass., report that their business for 1901 was largely in excess of the previous year, and the outlook for 1902 is more promising than at the same time last year. The demand in this country for their gauges and valves has not only increased, but their foreign business is crowding them. They also report that the sale of their Thompson indicator has steadily increased, until they feel there are now more Thompson indicators sold than all the other makes combined.

The Watson-Stillman Company, of New York, has just issued a new catalogue, No. 63, entitled "Hydraulic Valves and Fittings." In this catalogue only the most popular varieties of high pressure hydraulic valves and fittings are given. These include screw stem valves, plunger valves, balanced piston valves, balanced spindle, double valves, valves relating to accumulators and hydraulic check valves. This catalogue, like all others that have been issued by this company, is made up of separate sheets with the description and engraving of one machine on each sheet. These sheets are numbered and sent out separately on request. The complete catalogue can also be procured by those interested in this machine. Those applying by postal should give their position or the line of business.

"A Book for Club Women" is the title of a very attractive and pleasing pamphlet just issued by the advertising department of the Santa Fe Railway. The book is beautifully illustrated with views of verandas, courts, gardens and interior views of women's clubs. The text treats especially of home and club life, and of houses, gardens and domestic conditions, with a few words of information in the back of the book telling about the special excursion rates that will be in force during the National Convention of the Federation of Women's Clubs at Los Angeles, May 1 to 8, 1902. Any information regarding passenger rates, tickets, through car accommodations or other particulars can be had by addressing any of the passenger department agents of the Santa Fe Railway.

Mr. R. M. Dixon was elected Vice-President of the Safety Car Heating & Lighting Company and First Vice-President and Manager of the Pintsch Compressing Company at a meeting of the boards of directors of the above two companies on January 15, 1902. Mr. Dixon will have charge of the mechanical departments, embracing also adoption of all standards and experimental work, together with the construction and operation of the gas works. He will also have charge of the preparation of all applications for patents. The assistant engineers and superintendents of the gas works will report to him. In the absence of the president he will perform the duties assigned to the president by the by-laws of the companies.

At the same meeting Mr. D. W. Pye was elected Assistant to the President of the Safety Car Heating & Lighting Company and Second Vice-President of the Pintsch Compressing Company. Mr. Pye will have charge of the commercial interests of the companies and perform the duties of general purchasing agent. He will also perform such other duties as may be assigned him by the president.

"Record of Recent Construction, No. 30." This pamphlet of the Baldwin Locomotive Works contains an address upon compound locomotives, delivered by Mr. S. M. Vauclain last July. before officers and employees of the Union Pacific Railway, at Omaha. The address was illustrated by stereopticon views, and the pamphlet contains the most important of these, and a sliding valve diagram explaining the functions of the valves of the Vauclain system of compounding.

Sturtevant Dry Kilns.—This catalogue of 86 pages gives the essential principles of the Sturtevant hot-blast apparatus, together with information regarding the process of lumber drying and of the various designs of this company's dry kilns and apparatus. The engravings, which are of a high class of work, show only typical applications of the company's apparatus. In the back of the catalogue is a leaf forming pages 83 and 84, which is detachable and contains fourteen well-directed questions to be filled out and sent to the B. F. Sturtevant Company, Boston, Mass., by those wishing to have designs and estimates submitted on dry kilns.

With the rapid growth in the number of desirable winter resorts in the South there has also been a general development in the means of reaching these places, both by rail and water. To aid in selecting a resort at which to spend the winter the passenger department of the Lehigh Valley Railroad has issued a very attractively illustrated pamphlet giving the advantages, surroundings and facilities of the more important winter resorts in Florida, North Carolina, Virginia and New Jersey, together with routes by which they can be reached, the rates of fare and other useful information. All of these places are reached by the Lehigh Valley. A copy of this pamphlet can be procured by writing Mr. Chas. S. Lee, General Passenger Agent of the Lehigh Valley Railroad, 26 Cortland street, New York.

The J. A. Fay & Egan Company's new catalogue of standard wood-working machinery has been received. It is in keeping in every particular with the high standard of this company's machines. The J. A. Fay Company and the Egan Company have up to this time issued separate catalogues, but in this volume of 440 pages, of standard size, 9 x 12 ins., bound in heavy black cloth, the united efforts of the combined company (J. A. Fay & Egan Company) are shown in a complete line of new and improved machines. The contents of this book covers nearly everything in the wood-working line. The descriptions of the machines are clear and concise, and are illustrated by large woodcut engravings. The completeness of this catalogue, the interesting information and facts which it contains, makes it a reference book that every railroad or manufacturing company using wood-working machinery should possess. For additional information regarding this catalogue—Series L—address the department of advertising of the J. A. Fay & Egan Company, Cincinnati, Ohio.

EQUIPMENT AND MANUFACTURING NOTES.

CHICAGO PNEUMATIC TOOL COMPANY.

The organization of the Chicago Pneumatic Tool Company, of New Jersey, has been completed, and on December 31, 1901, took over the properties proposed; namely, the business and plants of the Chicago Pneumatic Tool Company, of Illinois, the Boyer Machine Company, of Detroit, Mich.; the Chisholm & Moore Crane Company, of Cleveland, Ohio; the Franklin Air Compressor Company, of Franklin, Pa., and the New Taite-Howard Pneumatic Tool Company, of London, England. The securities issued are $2,000,000 5 per cent. twenty-year gold bonds and $5,000,000 of common stock, there being only one kind of stock. There remains in the treasury, unissued, $500,000 of bonds and $2,500,000 of stock. The company starts with a working capital very largely in excess of one million dollars, of which more than 50 per cent. is in actual cash. It also starts with actual earnings by the constituent-companies, before this organization, at the rate of $700,000 per year, which, after paying fixed charges and sinking fund under the mortgage, leaves 11 per cent. earnings on the stock.

The directors of the company are as follows: Charles M. Schwab, President United States Steel Corporation; John A. Lynch, President National Bank of Republic, Chicago; John R. McGinley, capitalist and banker, Pittsburg, Pa.; James H. Eckels, President Commercial National Bank, Chicago; William B. Dickson, Assistant to President, United States Steel Corporation; Charles A. Miller, President Galena Oil Company; J. W. Duntley, President Chicago Pneumatic Tool Company; Joseph Boyer, President Boyer Machine Company, Detroit, Mich.; Edward Y. Moore, Vice-President Chisholm & Moore Manufacturing Company; Max Pam, Counsel; John Charles Taite, of Taite-Howard Company, of London, England; Charles Parker Whitcombe, of Taite-Howard Company, of London, England.

The Executive Committee is as follows: J. W. Duntley, Chairman; Charles M. Schwab, Max Pam.

The officers are: J. W. Duntley, President; W. O. Duntley, Vice-President; Edward Y. Moore, Second Vice-President; Ernest P. Wenger, Treasurer; H. R. Kent, Assistant Treasurer; Le Roy Beardsley, Secretary; S. G. Allen, Assistant Secretary; Joseph Boyer, Mechanical Engineer; A. J. Doughty, General Superintendent; Pam, Calhoun & Glennon, General Counsel.

The Executive Board has made the following appointments: W. O. Duntley, Vice-President and General Manager; C. E. Walker, Assistant General Maanger; Thomas Aldcorn, General Sales Agent; W. P. Pressinger, General Manager Air Compressor Department; Chas. Booth, Manager Chicago Office; S. G. Allen, Manager New York Office.

The West Virginia Central & Pittsburgh Railway has ordered 500 hopper cars of the Vanderbilt design, which was illustrated in our November number of 1901. These cars will be built by the Cambria Steel Company.

The Bullock Electric Mfg. Co. and the Wagner Electric Mfg. Co. have issued a card illustrating a single or multiphase motor direct-connected to a small centrifugal pump for apartment buildings where alternating current is the only available power. The pump delivers 25 gallons per minute, and will raise water 100 feet, if necessary. It is a compact unit, which will be exceedingly useful for auxiliary service in connection with large shop plants.

The O. M. Edwards Company, of Syracuse, N. Y., have secured the services of Mr. B. S. McClellan as traveling representative for the Edwards window fixtures, extension platform, trap door fixtures and other railway devices. Mr. McClellan is a practical railroad man, thoroughly familiar with current practice, and has a wide acquaintance from his connection with the New York Central as foreman of the passenger car shops at West Albany, and previous to that he held a similar position with the Illinois Central at New Orleans.

The general sales offices of the Pennsylvania Steel Company and the Maryland Steel Company have been moved to Philadelphia, located in the Girard Building. They will be represented by Mr. Howard F. Martin, General Manager of Sales of the Pennsylvania Steel Company. A local sales office will be retained at the Steelton plant for business in the vicinity of the works, and will be under the charge of Mr. Chas. W. Reinoehl, Sales Agent.

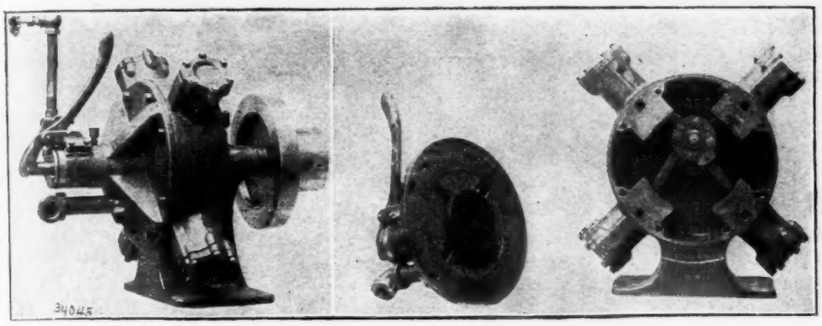
WANTED.—Experienced draughtsman with good knowledge of railway car construction. Address P. O. Box 1451, Pittsburgh, Pa.

WANTED.—Traveling salesman to represent railroad supply house in the South. Applicant must be well acquainted with the purchasing and mechanical department officials. Please answer, giving full particulars, experience, reference, etc. Address American Engineer and Railroad Journal, Morse Building, New York City.

WANTED.—Position as salesman or manager in Railway Department by a competent salesman having at least 20 years' experience. Answer J. B. H., care of this paper.

THE LEONARD HIGH-SPEED MULTIPLE-CYLINDER ENGINE.

The accompanying illustrations represent an improved steam or compressed air engine, designed to meet certain requirements where high speed and light powers are an advantage, as for detached machinery, pumps, dynamos and fans. It is also particularly adapted to launches and locomobiles, owing to its compactness and strength in design of frame, and because no working parts are exposed to gather dust and dirt.



Leonard High Speed Multiple Cylinder Engine for Light Powers.

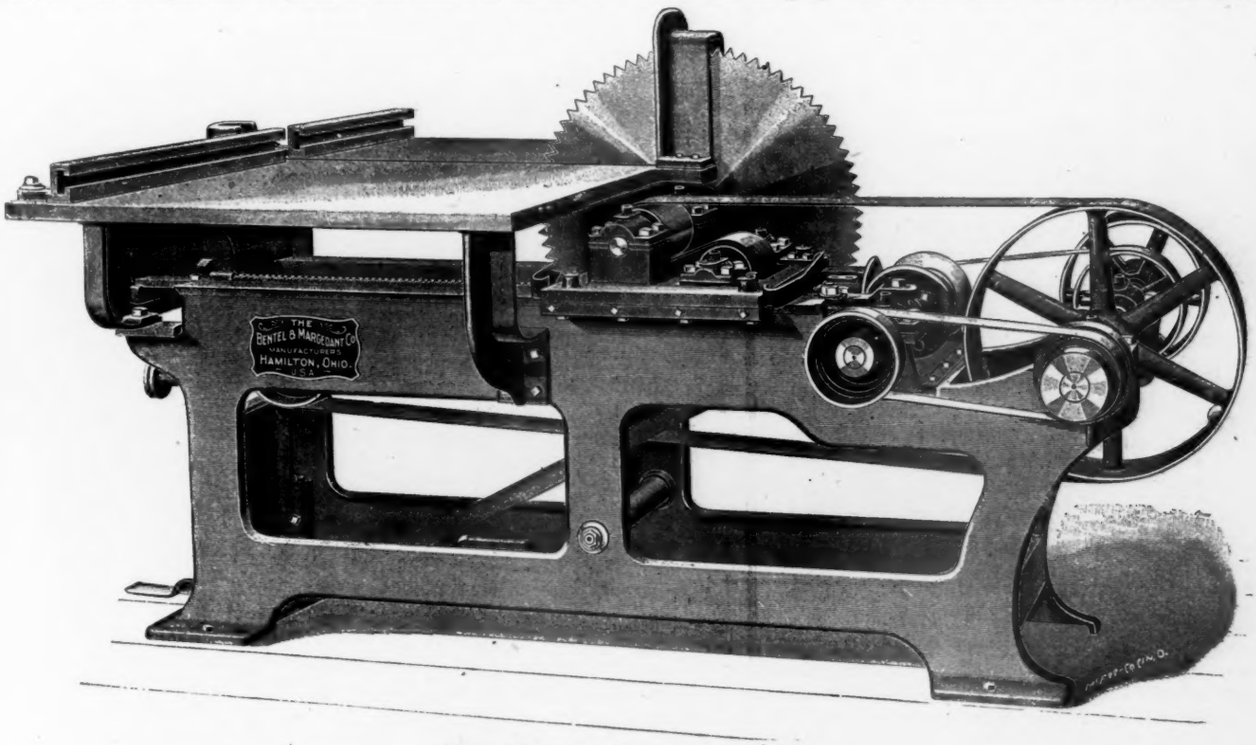
The most important feature of this engine is its simplicity, which will be apparent to all users of engines. There are very few parts, all of which are easy of access. There are only two places requiring packing. The first figure shows the complete engine as used for stationary purposes. It will be seen that the frame, cylinders and bearing are all cast in one piece. There are four single acting cylinders set at right angles to the crank shaft, which is made of one solid piece of steel. Four pistons with connecting rods are attached to an ingenious center bearing on the crank shaft, which runs in oil inside the frame casing. The engine is balanced, and, owing to the arrangement of cylinders the strain on the crank pin is nearly constant, as one cylinder is under pressure while the one at right angles is exhausting. The valve gear is of the rotary type, and very simple. It is operated by a disc as shown in the view with the valve casing removed. This valve is controlled by a lever having a ratchet stop, and by this arrangement the motion of the crank shaft can be reversed, the speed slowed down or stopped; also, by this same movement a variable cut off is obtained. This is a great advantage for use on launches or locomobiles, also for railroad and other shop use, as the engine is always under the control of the operator. The operation is as follows:

Steam is admitted to the side of the valve frame, passing through ports in the valve to the top of the cylinder and is exhausted back through the same valve to an exhaust chamber in the valve chamber, thence to the exhaust pipe. All wearing parts are bronze bushed and can easily be replaced. No attention is required to run the engine other than to keep the oil cups filled. There are no rods to key up, or knocking of moving parts inside the casing, as on most engines of this class, and an interesting feature is that the engine starts at once and at any point, either right or left, at the will of the operator. It is compact, strong, and light, compared with other small upright engines on the market. This engine is used with very satisfactory results in driving flexible shafts in locomotive and other similar work.

Further information may be had from Joseph E. Wise, The Bourse, Philadelphia, Pa.

HEAVY AUTOMATIC CUT-OFF SAW.

This machine is designed with a heavy central connected table or long extension roller table to be used for medium and heavy work of such dimensions as is required in car shops, shipyards and for heavy building material. It has a very heavy, well-braced frame 7 ft. 5 ins. long, which supports a table 5 ft. long by 3 ft. 4 ins. wide. As will be seen in the accompanying engraving the two halves of the table are strongly connected by a bridge over the saw, and each supplied with a section of fence to be placed either at the front

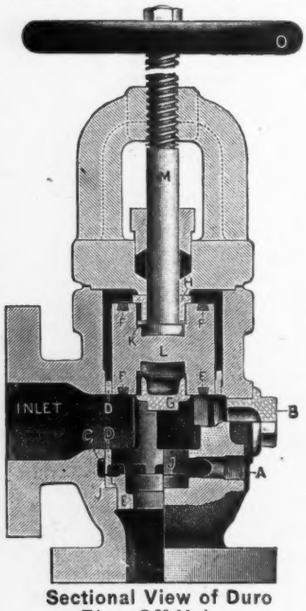


Heavy Automatic Railway Cut-Off Saw.
Bentel & Margedant Company.

or rear end of the table, as preferred. The machine is furnished with one saw 24 ins. in diameter, but saws up to 30 ins. in diameter can be used and will cut off material 27 x 6 ins. or 17 x 11 ins. The saw housing travels in dovetail slides and is provided with adjusting gibs for taking up wear and for lining up the saw. To allow the housing to move more freely and to do away with the swinging tension frame, the saw is driven by an improved endless belt which keeps the tension equal throughout the length of travel. The feeding of the saw housing is by means of a heavy lead screw which is made to rotate right or left through miter frictions which are thrown in and out of gear by a foot treadle. There are three rates of feed and a fast return feed. The saw can be started and stopped at any point in its travel and the speed of travel can be increased or diminished by the operator at will, through the medium of the foot treadle, which is under his direct control. On the countershaft, which is attached to the machine, are tight and loose pulleys 14 and 13 ins. in diameter, with 8¼-in. faces, of the Bentel & Margedant Company's patented construction. There has been specially designed, for the easy handling of heavy timbers, a long extension roller table. This is provided only by special order. The weight of this machine is about 42,000 pounds. Any information of a special nature regarding this cut-off saw machine No. 111 will be furnished upon application to the Bentel & Margedant Company, Hamilton, Ohio.

THE DURO BLOW-OFF VALVE.

The Lunkenheimer Company has just placed on the market a blow-off valve, made in three sizes, with flanges or screw ends and having a self-cleaning seat. This ingenious device consists of a plug which fits snugly in a separate and easily-removable bronze casing, which can be readily replaced when worn. Any accumulation of scale on the seat is prevented by a jet of steam blowing over the seat.

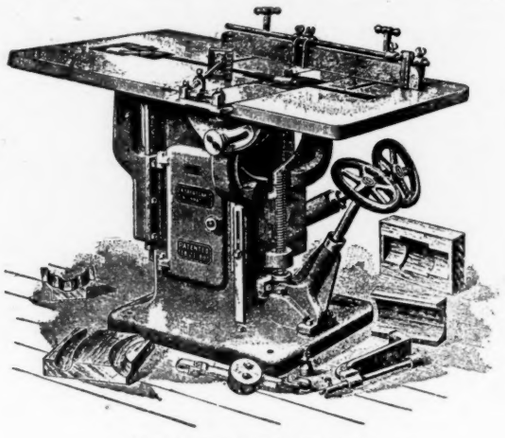


Sectional View of Duro Blow-Off Valve.

In the sectional view of this valve, shown in the accompanying engraving, it will be noticed there is a steam inlet, A, which connects with an annular passage, C. This inlet connects to the steam part of the boiler with a suitable valve interposed. The steam inlet A admits to C and J, and discharging from the latter, blows across the seat, cleaning off any scale or sediment that may have accumulated on it, so that the disc and seat bearing, when in contact, will be perfectly clean. The iron body of the valve has a brass casting, D, with a circular slot, J, cut into the side, at a point below the level of the seat, E. This casing is held in place in the body of the valve by the seat ring, E, both of which are removable at any time for repairs or replacement with new parts. In closing the valve the disc is screwed down, and the edge in passing the lower edge of the casing, D, cuts off a great deal of the flow of water and sediment. At the same time the valve in the steam pipe leading to the inlet, A, should be opened and the steam admitted to the annular space, C, from whence it passes through the slot J and blows off the entire surface of the seat, E. The disc on reaching the seat cuts off the flow of steam from the inlet, A, as well as the blow-off from the boiler. The valve in the piping leading to the inlet, A, can be left open at all times, as the disc on the blow-off valve would keep this outlet closed. The disc or plug is reversible, as it has two seating faces which can be changed at will, and thus increases considerably the durability and efficiency of the valve.

A NEW CORE-BOX MACHINE.

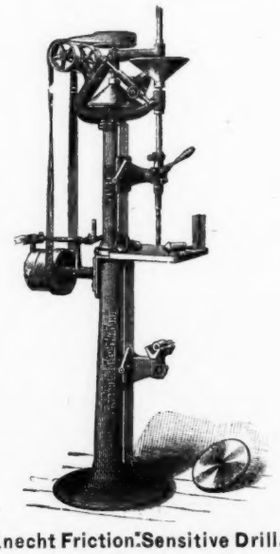
The accompanying engraving represents a new core-box machine which has been brought out by the J. A. Fay & Egan Company, and for which the makers claim great advantages in speed and accuracy for making all kinds of cored boxes and work that requires recessing and duplicating.


New Core-Box Machine.

This machine will cut semi-circular core boxes of any length, and from 1 to 20 ins. in diameter; also semi-circular core boxes closed at the ends with recesses of different diameters, and with corners of any desired shape. On patterns with internal curves, such as the inside of staves, cores and cutting out the under side of bosses to fit on rounded patterns, the work can be produced very rapidly. For making large fillets on engine and pump frames, and similar patterns, it is a great saving over the old methods of working the curve. It is not necessary that clear lumber be used when making cuts on this machine, as the cutters are so constructed that they will cut knotty lumber either with or across the grain and give it a smooth surface. To produce correctly such core boxes as elbows, a radius attachment is used with the machine. The heads used can be set for different diameters and are so made and set that the bits are adjustable. By this arrangement a fewer number of heads need be used to accomplish a wide range of work. The address of the J. A. Fay & Eagan Company is 409 Front street, Cincinnati, O.

KNECHT FRICTION SENSITIVE DRILL.

The frictional sensitive drill press manufactured by Knecht Brothers, Cincinnati, Ohio, is so evidently satisfactory wherever it is used as to justify our directing attention to it again in these columns. Its chief characteristics are the speed control, friction drive and variable power adjustment. The engraving shows the construction of the machine. The slide guiding the friction roller is graduated for the proper speeds for drilling cast-iron, the sleeve passing through the spindle head is graduated for the depth of hole, and a collar may be fixed for drilling a number of holes to the same depth. The machine is very convenient, and those using them say that the saving of broken drills pays for the machine in a short time. Further information may be had by sending for Circular No. 4, to Knecht Brothers Company, Cincinnati, Ohio.


Knecht Friction Sensitive Drill.